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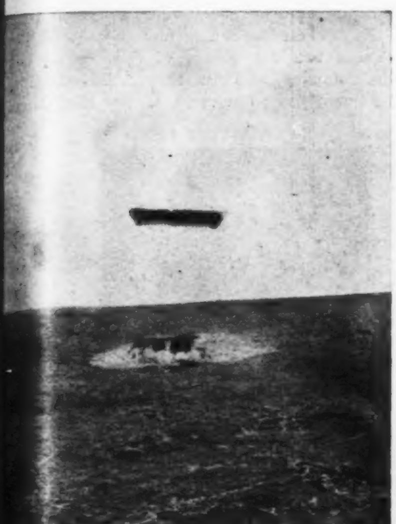
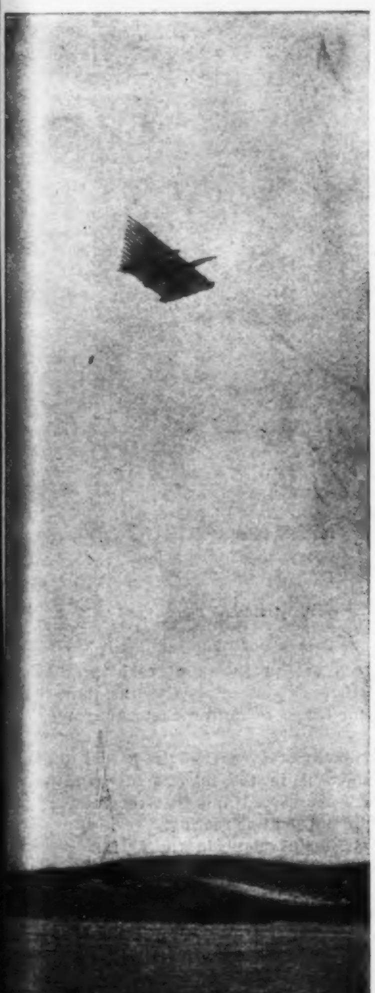


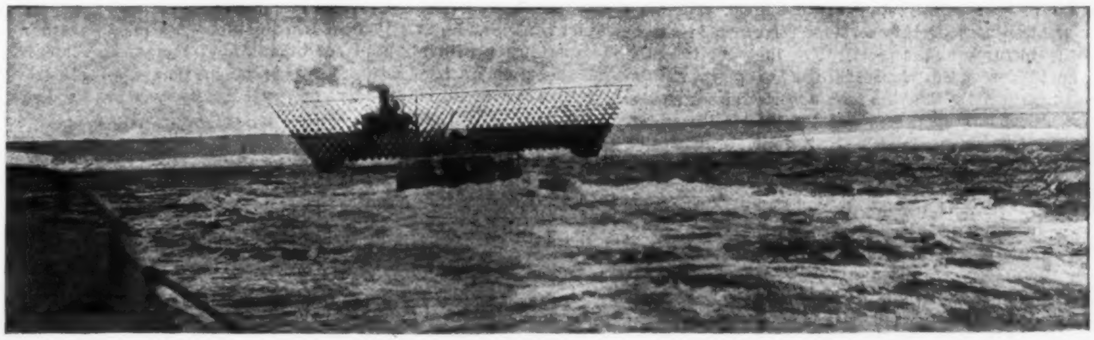
PRACTICE DRILL WITH A SMALL KITE.

The water shield in the bow keeps the men comparatively dry.

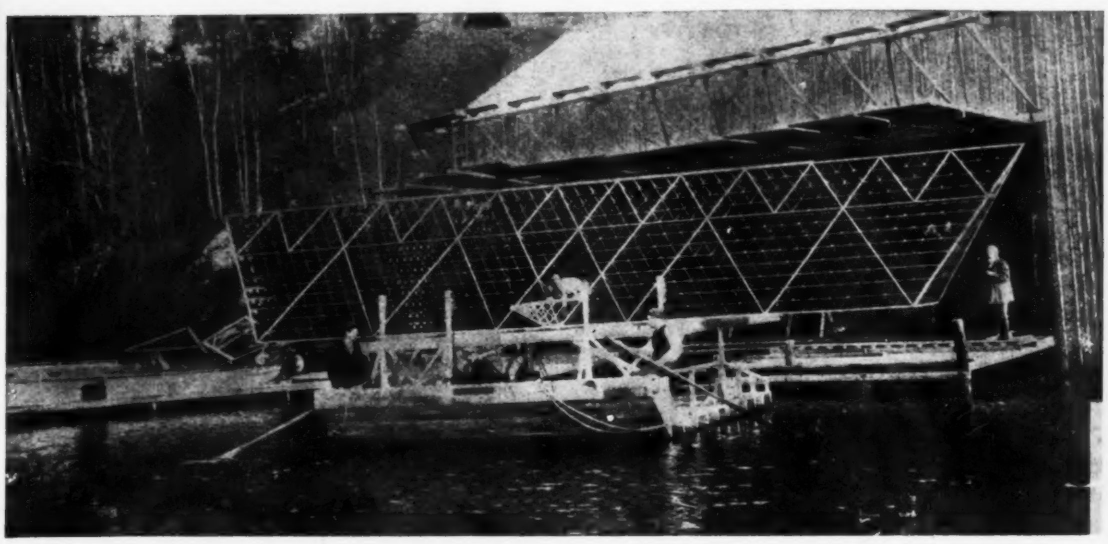


ANOTHER VIEW OF THE KITE ALOFT.

The pull on the flying line was greater than could be measured, but considerably exceeded 210 pounds.

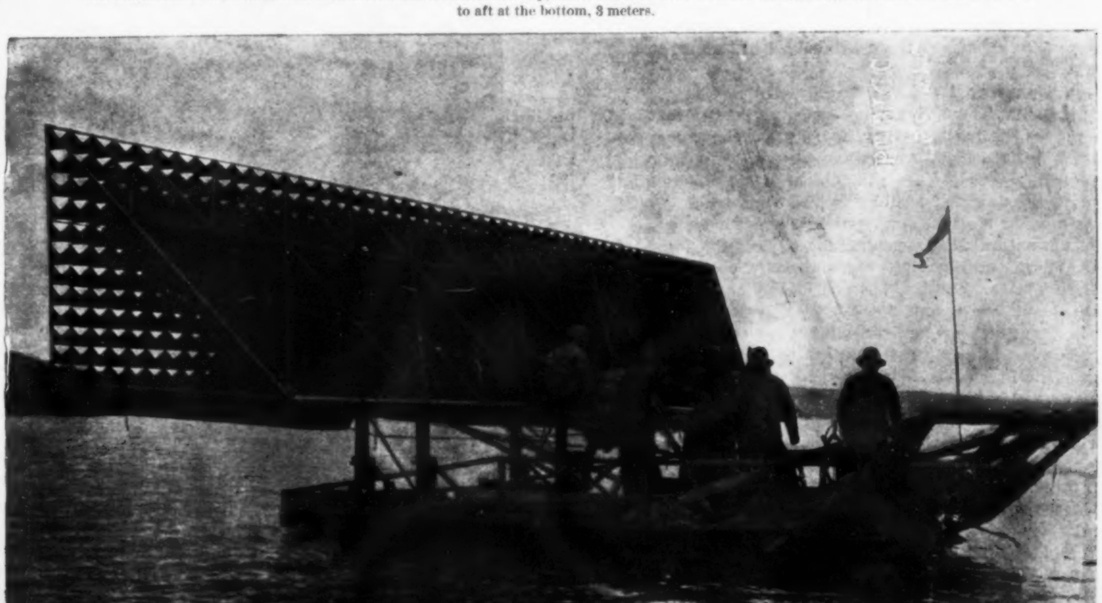


TOWING THE KITE WITH LIEUTENANT SELFRIDGE ABOARD.



FRONT VIEW OF THE "CYGNET," SHOWING THE MANHOLE IN THE CENTER.

The dimensions of the kite are: 13 meters from side to side on the top, and 10 meters on the bottom; oblique height, 3 meters; depth from fore to aft at the bottom, 3 meters.



FRONT VIEW OF THE RAFT AND KITE.

The high shield at the bow of the raft protects the crew from being deluged by water when the raft is towed rapidly.

DR. BELL'S MAN-LIFTING KITE.*

EXPERIMENTS WITH THE "CYGNET."

DR. ALEXANDER GRAHAM BELL'S gigantic man-lifting kite, the "Cygnet," was sent up in December, 1907, both with and without a man. The pictures show it aloft, carrying no weight, in flight when Lieut. Selfridge, of the United States Army, ascended to a height of 168 feet and remained in the air for over seven minutes.

While Dr. Bell's ultimate object is to secure a flying machine that will support itself in the air at a moderate rate of speed,† the experiments with the "Cygnet" have been mainly studies in stability. The wonderful steadiness of this form of structure is shown by the pictures and especially by the fact that the "Cygnet" descended from 168 feet to the water so slowly and evenly that the man aboard did not realize he was dropping until he found the kite in the water. The kite flew as easily with Lieut. Selfridge aboard as it had on the previous trial with no load, and could undoubtedly have borne a weight several times as great as that of one man. Owing to the severity of the winter in Baddeck, Cape Breton, Nova Scotia, where these experiments are being conducted, it has been necessary to postpone further flights until the spring, when the work will be resumed.

Dr. Bell's next step will be to put a powerful light motor on a modified form of the "Cygnet."

The photographs were taken by Mr. J. A. Douglas McCurdy.

THE COAL BRIQUETTING INDUSTRY IN THE UNITED STATES.‡

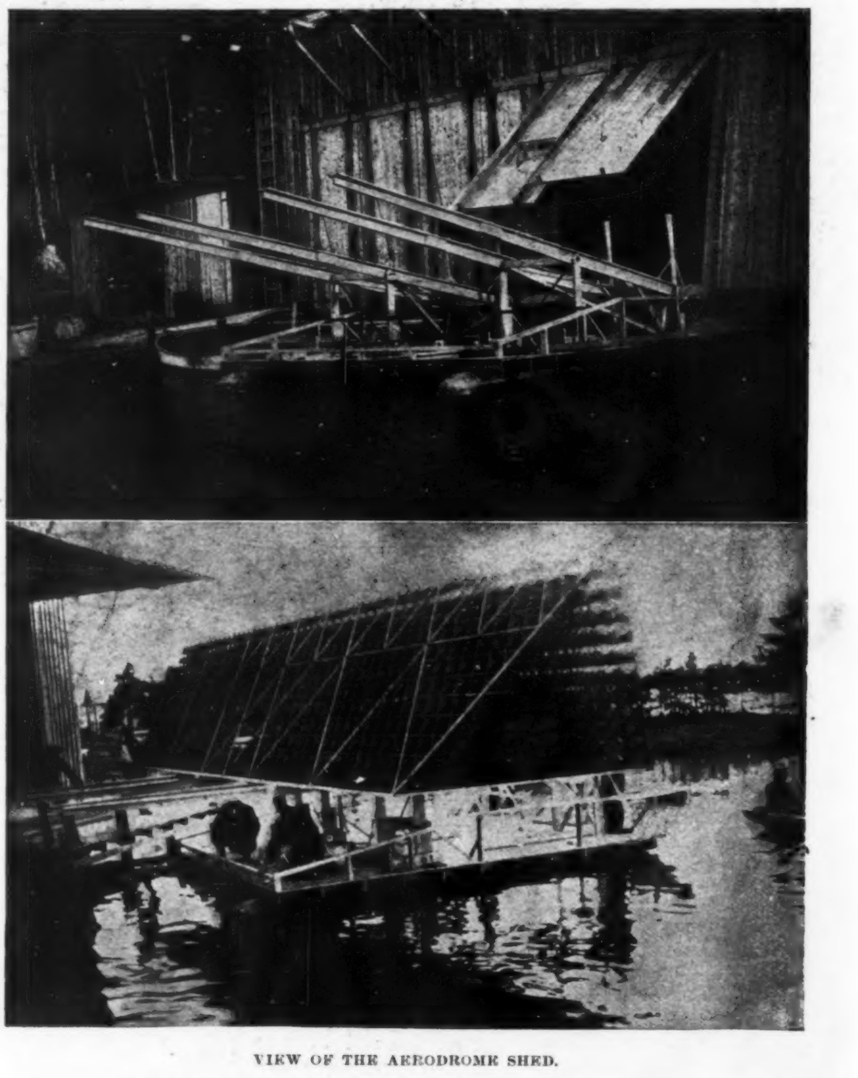
By EDWARD W. PARKER.

ALTHOUGH the briquetting of coals and lignites has been carried on for many years in Europe, and has reached a particularly high state of development in France, Belgium, and Germany, it has made comparatively little progress in the United States. The causes for the backwardness of the United States in this regard are several, and first among them has been the abundant supply of cheap raw fuel with which the manufactured article has to compete. With our millions of acres of coal-producing lands, in which the coal can in most places be cheaply mined, it has appeared in many districts to be more economical to waste the slack or culm, which constitutes a considerable percentage of the product, than to attempt to save it at the additional expense required for briquetting. For this reason large tracts in the anthracite region of Pennsylvania are covered by unsightly culm banks which encumber the ground and mar the view, and in some of the bituminous districts huge piles of unmarketable slack are allowed to burn in order to get rid of them. When the coal is of coking quality, or when the slack can be used for steaming purposes, these losses are not sustained, but many thousands of tons of material that might be converted into usable fuel have been wasted every year simply because of the increased expense involved in its preparation.

Another reason for the failure to build up a briquetting industry in the anthracite region of Pennsylvania, where the best opportunity for its development is offered, has been the opposition shown by some of the operators to the introduction of a manufactured domestic fuel which would come in competition with the prepared sizes of anthracite. And such an opposition is natural. The competition of bituminous coal has almost entirely shut out anthracite as a steam fuel. Coke for iron making has almost entirely supplanted anthracite, and the use for domestic purposes of coke and gas made from bituminous coal is growing. Owing to the greater depths to which the mining of anthracite is being carried, the thinner and less favorably located beds which are being worked, and the increasing cost of labor, the mining and preparing of anthracite is becoming more expensive on one hand, while competition is becoming keener on the other. A certain rate of production must be kept up for the protection of the properties themselves, and, when all the conditions are considered, the unfavorable attitude on the part of the operators toward further competition is at least realizable.

Still another reason which has been assigned, rightly or wrongly, for our halting progress in fuel briquetting has been the lack of assurance of a regular supply of coal-tar pitch at reasonably low prices. For out of the many attempts that have marked the incubating period of briquetting development—some of them costly—has grown the knowledge that coal-tar pitch must be relied on to supply, in the Eastern States at least, all or the greater part of the binding material. In California, Arizona, and other parts of the Far West asphaltic pitch, the residual product from the refining of the heavy asphalt-base petroleums of that region, has been and is now successfully used in recently constructed briquetting plants. But in the East coal-tar pitch is the base of the economically successful cementing material—a fact that has been fully demonstrated by the extended investigations carried on at the United States Geological Survey's fuel-testing plant at St. Louis.* These investigations included experiments with all kinds of organic and inorganic binders, embracing, besides coal-tar pitch, such materials as rosin, sugar-house refuse, molasses, acid sludge, quicklime, and various mixtures. The results show that coal-tar and asphaltic pitch are the only really successful binders. Any materials used with them must possess above all others the essential virtue of cheapness.

But while it is claimed on one side that the briquetting industry has been held back by the lack of assurance of a steady supply of coal-tar pitch, it also happens that one of the reasons assigned for the comparatively slow development of the by-product coking ovens in the United States in the last few years is the lack of a profitable demand for coal tar, an important by-product of retort coke ovens. It is well known that the demand for creosoting oils to be used by railroad companies for preserving ties, bridge timbers, etc., is far beyond the present domestic production of that coal-tar product, and the statistics compiled by the Bureau of Statistics of the Department of Commerce and Labor show that our imports of the chemical products of coal tar amount to over $10,000,000 in value yearly. To the ordinary observer it would appear that the conditions here presented afford an opportunity for the recognition of a community of interests which may be profitable to the manufacturers and beneficial to the general public.



VIEW OF THE AERODROME SHED.

Showing the raft with its long tilting arms backed up against the building to receive the giant kite. The "Cygnet" placed on board the raft.

The constantly increasing expense involved in mining and preparing anthracite coal is slowly but surely making that commodity more and more a luxury, and manufactured fuel which will take the place of anthracite for domestic use, particularly among consumers of moderate means, appears to be needed. This is especially true in the northeastern section of the United States.

Two of the briquetting plants, which have been recently constructed, and which are discussed in detail in the following, indicate somewhat a "getting together" of the coal-tar producing and the briquetting interests. These are the plants of the United Gas Improvement Company, at Point Breeze, Philadelphia, and of the Semet-Solvay Company, at Del Ray, Mich. Both companies are producers of coal tar, and the plants have been constructed for the purpose of briquetting mixtures of anthracite culm and coke breeze.

It appears now, moreover, that the period of failure and discouragement in the manufacture and use of briquette fuel has passed and that the industry will be placed on a substantial footing.

The first successful plant in the United States of which the writer has any definite knowledge was built at Stockton, Cal., a few years ago by the San Francisco and San Joaquin Coal Company. This plant, unfortunately, was entirely destroyed by fire in 1905, and the plans for its reconstruction at San Francisco were interrupted by the earthquake and fire which destroyed a large portion of that city in April, 1906.

During the last two years a number of briquetting plants have been built. Some of them have been put in operation since January 1, 1907.

NEW YORK, N. Y.

New Jersey Briquetting Company.—During 1904 and 1905 the New Jersey Briquetting Company, of New York, constructed at the foot of Washington Street, Brooklyn, a plant for exploiting the Zwoyer Fuel Company's briquetting process. This plant was intended to be operated in connection with a coal yard

* Reprinted with the illustrations by courtesy of National Geographic Magazine.

† See "Aerial Locomotion, with a Few Notes of Progress in the Construction of the Aerodrome," by Dr. Alexander Graham Bell, SCIENTIFIC AMERICAN SUPPLEMENT, Nos. 1638, 1639, 1640.

‡ From a United States Geological Survey Bulletin.

* Bulletins of United States Geological Survey Nos. 261 and 290; Prof. Paper United States Geological Survey, No. 48.

on Adams Street, but during the construction of the piers and anchorages for the new Manhattan Bridge the company was prohibited from operating the tramway from the coal yard to the plant. This interfered with the operations of the plant, and as extensive storage capacity, either for raw material or for the product, had not been provided for at the site, the work done has been accomplished under much disadvantage. The prohibition put on the tramway and the lack of dock facilities for loading and unloading material has crippled the plant to such an extent that what was supposed to be an excellent location has turned out to be an unfortunate one. As a result of these unfortunate conditions it is proposed to remove the plant to a site better adapted for receiving, storing and shipping the material.

A description of the plant in Brooklyn was published in the Iron Age, from which the following notes have been in part abstracted, additional matter having been furnished by Virgil H. Hewes, treasurer of the Zwoyer Fuel Company.

Prior to the construction of the plant in Brooklyn the Zwoyer Fuel Company had built a small plant in Jersey City, N. J., which was of sufficient capacity for experimental work, but not large enough to be operated as a commercial undertaking, and was abandoned. It may be stated here that, after a considerable expenditure of time and money in experimenting with different kinds of binders, coal-tar pitch was finally selected as the best material suited to the work, a decision which has been generally reached in the Eastern States, asphaltic pitch having been adopted in the Far West, where that article is cheaply obtained. During the progress of the experimental work about [illegible] tons of briquettes were made with a binder composed of $6\frac{1}{4}$ per cent of rosin and oil, $1\frac{1}{2}$ per cent of flour and water, and 6 to 10 per cent of bituminous coal, the body of the briquette being anthracite dust. About 900 tons were made with 5 to 7 per cent of rosin and oil and 10 per cent of bituminous coal, 400 tons were made with 5 to 7 per cent of wood pitch and [illegible]0 per cent of bituminous coal, and 1,500 tons were made with 6 to 7 per cent of coal-tar pitch alone. In applying the binder during the last three experiments an atomizer was used.

The plant in Brooklyn has a capacity of 10 tons an hour and was built for the purposes of demonstration. During the winter and spring of 1905-6 about [illegible],000 tons of anthracite briquettes were made and sold. The price received was $5 per ton of 2,000 pounds at the plant, $5.50 per ton delivered, and $6.60 per ton in bags of 100 pounds each. These prices were 50 cents below the prices of the domestic sizes of antnracite.

The building is nearly triangular in outline. The anthracite dust is received on Washington Street at the end of a screw conveyor, which carries it to the foot of an elevator, where it is lifted to the top of the plant and spouted to a screen located over the dust bin. The coarser material is spouted either to the boiler room or to an oversize bin in the rear of the dust bin and then fed into a crusher, crushed and passed to the foot of the dust elevator, where it is again carried to the screen. The dust is drawn from the dust bin by a conveyor, driven from a variable-speed countershaft, and is fed to the 16 by 36-inch roll crusher. It then passes to an elevator and is carried to the mixers. After passing through six mixers it is carried to the second floor, where it falls into the press hopper.

From the press the briquettes are carried by a belt conveyor to the baking oven (when smokeless briquettes are wanted) and are then elevated to and distributed upon the cooling table, which is located on the second floor. After cooling, the briquettes are run into chutes and loaded into wagons for delivering, or are stored. In New York the briquettes sell readily when not baked.

On one side of the dust bin there is a bin from which soft coal is fed into a 19 by 4-inch roll crusher and passed to the same elevator that carries the dust to the mixers. Development has shown that it is not necessary to use soft coal with anthracite dust. However, this bin is used when experimental runs are made requiring the mixing of different materials with the dust.

The binder used is coal-tar pitch, which is received in barrels on the Plymouth Street side of the building. It is hoisted to the second floor by means of a barrel hoist; the staves are then removed and the pitch is thrown into the binder melting tank (a tank holding about 15 tons of pitch) and pumped by means of a rotary pump into the storage or hot binder tank, where it is kept heated.

The number of units necessary in a mixer depends on the material to be briquetted and the condition in which it is received. At this plant six mixers are used, which have proved well adapted to the handling of coal (hard and soft, wet or dry), coke breeze, and even iron concentrates.

The dust enters mixer No. 1, and is carried through mixers Nos. 1 to 6, and then by conveyor to the press. In passing [illegible] Nos. 1 and 2 the dust is heated by furnaces to drive off all the moisture. The coal-tar pitch, which has been previously heated, is pumped from the storage tank by a small rotary pump driven from a variable-speed countershaft, which regulates the percentage of pitch used. The pitch is atomized by means of a steam jet and delivered to mixer No. 3.

The above apparatus and process are patented.

A press of the roll type is used, the rolls being built up of disks which are milled to form the pockets and then assembled and bolted together on the shaft. This method of constructing the rolls, as well as the design of the briquettes, is patented. Briquettes are made in two sizes—$1\frac{7}{8}$ by $1\frac{7}{8}$ by $1\frac{1}{4}$ inches and $2\frac{1}{8}$ by $2\frac{1}{8}$ by $1\frac{3}{8}$ inches. The briquettes are square "pillow" or "pin-cushion" shape. The smaller ones weigh 2 ounces and the larger 3.3 ounces.

The cooling table consists of three endless belts composed of steel plates carried at their ends by sprocket chains. The belts are placed one over the other and carry the briquettes back and forth six times over a distance of 84 feet, making a total travel of 504 feet. The briquettes are then run into bins or loaded into wagons.

Staten Island Plant.—The Briquette Coal Company, New York city, has just completed the construction of a briquetting plant at Stapleton, on Staten Island. This plant is constructed for the purpose of using anthracite dust as delivered at the plant, with coal-tar pitch as the basis of the binding material. The plant does not possess any novelties in its design except that there are two presses of radically different types. One of these is of German manufacture, having been built at tne works of Schuchtermann & Kremer, of Dortmund. This press is of the plunger type and in the manner of feed, compression, and ejection is similar to the Johnson (English) machine used at the Geological Survey testing plant at St. Louis, except that the disk containing the compressing molds is set and revolves horizontally instead of vertically. The briquette is a parallelopiped in shape, with the end edges rounded. The dimensions are $4\frac{3}{4}$ by $2\frac{1}{4}$ by $2\frac{1}{2}$ inches and the briquettes weigh about 1.5 pounds. They have a specific gravity of about 1.24.

The second press is of what is generally classed as the Belgian type, similar to the one described as the "American" machine used at the Geological Survey testing plant. This particular machine was made at the works of H. Stevens, at Charleroi, Belgium. The product is of the eggette pattern, which is more desirable for domestic use than the larger briquette. The eggettes weigh about 5 ounces and have a specific gravity of 1.37. The total capacity of this plant, with both presses in operation, is 120 tons of briquettes per day of ten hours. The German machine will turn out $4\frac{1}{2}$ tons and the French machine $7\frac{1}{2}$ tons per hour.

South Brooklyn Plant.—Another plant, which has just been completed as this report is written, is that of the National Fuel Briquette Machinery Company of New York city. This plant is located at the foot of Court and Smith Streets, Brooklyn, close to the Gowanus Canal, by which the materials to be used can be brought in barges and discharged at a minimum of expense. While intended to be operated on a commercial basis, it may be considered rather as a demonstrating plant. It is planned to use anthracite dust, with coal-tar pitch as a binder. The press is of the Belgian type, producing eggettes or "boulets" somewhat smaller than an ordinary hen's egg, and made exclusively for domestic use. The machinery used in this plant was patented in this country (United States patent No. 799,149, September 12, 1905) by Robert Devillers, with whom the writer visited the plant and to whom acknowledgments are made for courtesies extended. The eggettes here produced are much smaller than those ordinarily made, weighing only about 1.5 ounces each. They have a specific gravity of 1.3.

North American Coal Briquette Company.—This company has been incorporated for the purpose of exploiting the Forst briquetting process. The main feature of this process consists in the material to be used as a binder, part of which is kept secret, but which consists principally of coal-tar pitch. The merit claimed for the secret ingredients of the binder is that they permit a great economy in the quantity of binder used for the manufacture of superior briquettes. The company has negotiated for the purchase of a Duprey (French) machine, and has sent 10 tons of anthracite coal and 1 ton of binder to Paris for the purpose of demonstrating the claims made for this process.

The Mashek Briquetting Process.—The briquetting press designed by G. J. Mashek was described in detail by him in the Iron Age of April 19, 1906. It was designed for the purpose of overcoming the objections to the use of briquetting machinery which had developed principally through the failure of certain foreign-made machines to meet the requirements of the American trade. When Mr. Mashek started on the development of his plans, in 1903, the general type of machine in use in Europe was that which made large, rectangular-sided briquettes weighing from [illegible] 20 pounds each, and these proved unsuitable to American use. In designing his press Mr. Mashek adopted the Belgian idea of molds contained in the peripheries of two tangential wheels, but, instead of the eggette pattern, developed one which minimizes the blank spaces between the molds and produces a briquette of pillow or pincushion shape.

The Traylor Engineering Company has recently built for E. B. Arnold a Mashek press, which has been installed at the foot of West Forty-seventh Street, New York city. The building was designed and erected for, and originally equipped with, a different type of machinery, but the briquettes made proved to be of a shape and character unsuited to the trade, and the cost of manufacture was also too high to enable the briquettes to compete with natural coal. When it was decided to substitute a Mashek press for the old one, it was also deemed advisable to use the same building, which is a substantial one, and also as far as possible the old machinery (such as elevators, shafting, power plant, etc.), which was practically new and in good order, but which did not permit the most desirable arrangement.

The new press installed has a capacity of about 14 tons of 2-ounce briquettes per hour, but on account of the inconvenience resulting from the use of so much of the old equipment it is impossible to handle sufficient material to keep the machinery running at its full capacity and it is now operated at the rate of about 10 tons per hour. The cost of labor, fixed charges, and other expense being the same, the cost of production is slightly higher per ton of briquettes than it would be if the plant were operated up to its maximum capacity. The size of the briquettes has been determined by putting them on the market and selling them for domestic purposes, starting with 1-ounce briquettes and running up to 3 ounces. It was found that the majority of users preferred a 2-ounce size, which corresponds with the "stove" size of anthracite. The weight, of course, will vary with the nature of the dust from which the briquette is made, and it has been found that in using coke breeze a $2\frac{1}{2}$-ounce briquette is most desirable, and about a 3-ounce if made of soft coal and lignite. The press is so designed that a change of the mold shells can be made in about two hours.

The anthracite dust is elevated to the dust bin, from which it is drawn by a feed conveyor so arranged that the feed is constant and can be regulated as desired. This conveyor discharges into a chain elevator, which in turn discharges into a battery of five 18-inch rotary driers and heaters. These are superimposed one above another and all bricked in. The material is conveyed through these driers by means of screw mixers until it passes into the elevator.

On the side of these driers is constructed a furnace, the products of combustion from which are distributed into the driers through openings into the different units, so that no unit gets heat sufficient to either char the dust or burn out the ironwork of the paddle conveyor. An exhaust fan draws off the products of combustion and the moisture. The temperature of the discharge gases and moisture from the drier rarely exceeds 212 deg. F. After the material passes out of the drier into the elevator it is raised and dropped into a 36-inch Williams pulverizer, which crushes the larger pieces so that everything passes through about a 12-mesh screen. From the pulverizer the material is again elevated to another series of mixers and coolers similar in construction to the driers. At this point the anthracite dust has a temperature of about 300 deg. F. The coal-tar pitch is here introduced by means of a pitch pump so arranged that it will deliver a definite quantity of pitch, as desired. Alongside of the last battery of mixers is a small furnace which heats the two upper mixers, maintaining an even temperature in the mixture and not allowing it to stiffen or set. From the last mixer the material drops to an elevator that takes it up to the second floor and discharges it onto an 18-inch belt conveyor, which delivers the material into the hopper of the press. The press is run continually, discharging the briquettes into a perforated pan conveyor, which conveys them to the briquette bin. While in this conveyor the briquettes are subjected to a heavy spray of water in order to cool and clean them.

The coal-tar pitch used in this plant is of the ordinary roofing hardness. It is delivered by lighter on the adjacent dock and carted to the pitch-melting house, where it is melted in a tank, 6 feet wide, 12 feet long, and 8 feet deep. This tank will hold about 22 tons of pitch, which requires approximately twenty hours to melt. After the pitch is melted and brought up to the proper temperature for use, it is drawn off by means of a large pitch pump into the "prepared-pitch tank," from which it is poured into the mixers.

This plant requires about 125 horse-power to turn out 10 tons per hour. It has been in operation about two months and is said to be giving excellent results. The product is used almost entirely for domestic purposes and commands the same price as the best grade of prepared anthracite coal in the New York market. A large portion of the output is put up in paper bags [illegible]

and handled by grocers and small coal dealers the same as charcoal or crushed coke. The bag trade caters to the poor people who do not buy in large quantities and is a considerably cleaner method of distributing the product than that formerly used.

The briquettes are handled in the same way as ordinary coal, and experience in this and other plants has shown that abrasion or breakage averages about 3 per cent, which is slightly less than that with ordinary prepared coal.

PENNSYLVANIA.

It might be supposed that the briquetting industry would have its greatest development in or near the anthracite region of Pennsylvania, where a plentiful supply of raw material is available in the great culm banks created through many years of mining and in the still large amount of fine coal produced at the breakers for which no profitable market has yet been found. Up to the present time, however, there are but two briquetting plants in operation in the State, and one of these is located at Point Breeze, in the city of Philadelphia. The other is located at Dickson, a few miles from Scranton. Both were put into operation in 1906. The plant at Dickson is in the immediate vicinity of the mine of that name operated by the Delaware, Lackawanna & Western Railroad, and uses the fine coal or screenings, below marketable sizes, that come from the washery operated in connection with the mine. The owner of this plant, the Scranton Anthracite Briquette Company, withholds information relative to the details of its operations.

The plant at Point Breeze is owned and operated by the United Gas Improvement Company, and was constructed for the purpose of utilizing the coke breeze produced at the gas houses of the company. As at the Dickson plant, the product is not placed on the market, but is used by the company in its retorts for the manufacture of water gas.

It has been found advantageous to use a mixture of anthracite culm and coke breeze, with 5 to 7 per cent of coal-tar pitch as a binder. The proportions of culm and coke used are variable, according to the quantity of material on hand. At the time the writer visited the plant (November, 1906) three parts of culm to two parts of coke were being used. The press is of the Belgian type, producing eggettes about the size of a goose egg. The rated capacity of the plant is 10 tons of eggettes per hour. It has been in operation regularly, producing 90 tons per nine-hour day, except when it has been shut down for repairs and changes.

The breeze or screenings from the coke screens fall into a pocket or hopper, into which is also dumped the culm. The contents are raised by an elevator into a storage tank, discharging through the funnel-shaped bottom onto an automatic feed table, by which a measured stream of the material is continuously poured, part into the crusher and part directly into the hopper below the crusher. The material is then elevated and discharged into the drier. The dried material, together with the dust from the dust chamber of the drier, is elevated and discharged through a shaking screen into a storage tank located above the mixer. All material not fine enough to pass through the screen is returned to the crusher. The dried material is discharged through the funnel-shaped bottom onto an automatic feed table, by which a measured stream is continuously poured into the mixer. Into the feed end of the mixer is also poured a continuous stream of liquid pitch through a positive measuring faucet driven from the driving mechanism of the mixer through a variable speed device. The pitch is brought into the building as broken from the pitch bays of the tar distillery, fed into a pitch cracker, elevated and discharged into large steam-heated pitch storage tanks, where it is melted. From these tanks the melted pitch is drawn, as required, into a smaller steam-heated tank, to which the faucet previously mentioned is attached.

The warm, dry, and continuously measured crushed breeze and culm, together with the melted and continuously measured pitch, are thoroughly mixed and kneaded in the steam-jacket mixer. The mixed mass is discharged from the mixer, divided into two streams, and carried by two mixing conveyors, allowing time for cooling and setting, into the feed pans of the two presses, purchased in France. The presses form the eggettes and discharge them onto the shaking screens below, which screen out the waste and fines. They are then discharged onto a woven-wire belt conveyor, on which they have time to cool and set, and conveyed either to the cars or to the hoppers from which the buggies for the generator house are filled.

The waste and fines from the shaping screens under the presses are conveyed by conveyors to a hopper at the discharge of the drier

Screenings from the eggettes taken from the storage piles are returned by an elevator to the discharge of the mixer and assist in the cooling of the heated mixture. (To be continued.)

Roscoelite, a vanadium mica, occurs in Colorado, where it was mined and reduced during 1906. The mineral contains about 2 per cent vanadium.

Correspondence.

THE RELATION OF THE GOVERNMENT TO THE DEVELOPMENT OF SUBMARINE VESSELS.

[IN publishing the following letter from Mr. R. G. Skerrett, the Editor disclaims all responsibility for the statements made. On account of the great length of the letter, we have decided to publish it in two issues. The second half will appear in the next issue.]

To the Editor of the SCIENTIFIC AMERICAN SUPPLEMENT:

The departure of the battleship fleet has left the Atlantic seaboard sorely crippled so far as the mobile defense of heavy fighting ships is concerned. Should circumstances develop threatening hostilities, the cities of the eastern coast could readily be laid under tribute or reduced to ashes by any one of the principal foreign powers. This fact has called forth earnest protest and has given occasion for a determined move to effect legislation providing for a large number of submarine boats in lieu of the regular departmental recommendation for four first-class battleships and only four submarine vessels.

Setting aside the unwisdom of substituting submarines for battleships, the present effort to secure an increased provision for under-water craft could well be justified if the bill had not been drawn in a restrictive manner for the promotion of a single type of boat. This is not in keeping with technical advance, nor does it make for the nation's security viewed in the light of the state of the art in its widest developments.

The present appropriation bill as reported by the Committee on Naval Affairs of the House of Representatives reads as follows:

"The Secretary of the Navy is hereby authorized and directed to contract for eight submarine torpedo boats, in an amount not exceeding in the aggregate three million five hundred thousand dollars, and the sum of one million is hereby appropriated toward such purpose, and to remain available until expended: provided, that all said boats shall be of the same type heretofore determined to be the superior as the result of the comparative tests held under the provision of the Naval Appropriation Act approved June 29, 1906, and March 2, 1907, unless on or before October 1, 1908, a submarine boat of different type and of full size for naval warfare shall have been constructed and submitted to the Navy Department for like trial and by such like trial by said Department demonstrated to be not inferior to the best submarine torpedo boat in the competitive competition above referred to."

Apart from specifically providing for only boats of the diving type like that of the "Octopus," the vessel indirectly described in the above draft, the indulgence offered a possible competitor is so limited as to make it prohibitive. The "Octopus" was contracted for March 6, 1905, and was to be delivered to the government by September 6, 1906. The vessel was not launched until October 4, 1906, she was not ready for acceptance test until April of 1907—assuming that she had then been submitted for acceptance trial instead of the competitive tests which took place at that time—and the vessel is still undergoing repairs and has not been finally accepted by the government. If a rival craft must meet the accomplishments of the "Octopus," it is hardly to be expected that a full-sized vessel fit for naval warfare could be built and ready for official examination between the passage of the foregoing bill and the 1st of October of the present year. It was the manifest spirit of unfairness to the American inventor of the foregoing congressional provision which provoked the Hon. George L. Lilley, of Connecticut, to demand the present investigation.

That the United States government has not been unmindful of the submarine boat is proved by the fact that we have built or building to-day no fewer than nineteen submarines, representing a continuous encouragement to the development of a particular type of such boats during a period of thirteen years, and involving the expenditure and obligation of nearly four and a half millions of dollars. This sum does not represent the half million more spent in repairs, salvage, administration, and the vitally necessary modifications demanded after experiments.

The taxpayers of the country have a right to know if this substantial bounty of nearly five millions of dollars has brought a corresponding measure of national security against the day of possible need. The public has a right to know if all of the sources of native skill have been drawn upon in this developmental work pursued by the government. And the people have a right to ask, "Have we secured the best to be had for the prices paid?"

It has been shown by competent authorities in their testimony before congressional committees that the prices paid for the submarines now in the United States navy were out of all reason *unless the cost of development had been borne by their builders*. This [illegible] point of the whole question, because official testimony shows that the prices paid were nearly double the cost of construction plus a handsome profit.

DID THE DESIGNERS AND BUILDERS PAY FOR THEIR OWN EXPERIMENTATION?

In 1895 the John P. Holland Torpedo Boat Company was awarded a contract for one submarine boat, later known as the "Plunger." Speaking of that vessel, Mr. Charles E. Creecy, on behalf of the John P. Holland Torpedo Boat Company, testified on June 11, 1901, as follows:

"When we got to the Navy Department, the Secretary determined to put us in competition. *We had nothing but plans*, and nobody else had anything but plans."

It is not vital to the present issue to go into the details of construction of that impracticable craft. It is only necessary to say that those interested have stated that the real cause of the boat's failure was due to the manner in which the Navy Department interfered with the original design and insisted upon an installation of steam machinery and other features not contemplated by Mr. Holland. Rear-Admiral George W. Melville, in his evidence before Congress in May of 1902, has stamped that charge as absolutely false; and the author has in his possession plans sent him by Mr. Holland bearing date of June 12, 1893—a week prior to the opening of bids at the Navy Department—in which a steam boiler and other features are shown since charged to governmental interference.

Rear-Admiral Melville further testified that the Board on Construction, of which he was a member, were unanimous in their belief that the design presented by Mr. Holland would never produce a successful boat; but he urged the Secretary of the Navy, then Mr. Herbert, to award a contract to the John P. Holland Torpedo Boat Company on the ground that Congress had provided the money for *experimental purposes*, and that only by carrying out the intent of Congress would they be able to prove or disprove the practicability of the proposed craft. That was the beginning of governmental experimentation.

As the "Plunger" progressed, the John P. Holland Torpedo Boat Company was paid successive installments of the contract price, and these part payments not only constituted reimbursement for the cost of construction, but included the profit the contractors expected to make. After more than five years of delayed construction—during which time the boat had served the profitable commercial end of stock selling and advertising—she was utterly abandoned, and the money paid out by the government was in effect refunded. But this refunding had a string to it. The John P. Holland Torpedo Boat Company imposed as a condition that it should receive a new contract for a vessel of later design but of about *half of the promised accomplishments of the original "Plunger"* and at a cost of $20,000 more. By this arrangement, the interest on the ninety-odd thousand dollars paid out during that time went as so much profit to the Holland Company, and not a word was said about paying to the government the $80,000 in penalties due for delay which had accrued against the "Plunger" during the five years of her building. By the contract, the "Plunger" was to have been completed within twelve months from the date her contract was signed.

In 1896 the Holland interests secured the passage of a bill providing for the construction of two boats of Holland design, *in case the "Plunger" should prove a success;* but at the time of the passage of that bill *the keel of the "Plunger" had not even been laid*. The John P. Holland Torpedo Boat Company recognized that it could not hope to profit by that appropriation if the "Plunger" were to be depended upon to that end; and accordingly, later in 1896, they began the construction of that modest little craft since known as the "Holland."

It was not until 1898, however, that this small boat was able to maneuver with the required measure of certainty and security; and it was not until 1899 that she was able to meet the indulgent requirements outlined by the Department with due regard to the modest possibilities of that particular vessel.

This is what Mr. E. B. Frost, then secretary of the company, has said regarding the reasons for building the "Holland." His letter is dated April 28, 1900, and was addressed to the Hon. Eugene Hale, chairman of the Senate Committee on Naval Affairs:

"The company found after a year's work upon the 'Plunger' that she could not be made to bring out the *highest developments of the art*, and therefore determined to build the 'Holland' at its own expense which embodies *the inventor's most advanced ideas*. The success of the 'Holland' has shown the wisdom of the company in this respect."

"The highest developments of the art" was submitted to the Navy Department in 1898 for official examination, but the vessel failed to meet the Department's requirements, modest as they were. After a year's delay, during which time persistent efforts were made to improve the vessel's performances, the "Holland" was again submitted for test, and under date

of November 9, 1899, a board of naval officers reported upon the result of that examination. The following tabular statement will show how much the inventor's ideas had really advanced in six years:

	Promished 1893 Original "Plunger."		Realized 1899 "Holland."	
Displacement submerged.	138.5	tons	74	tons
Propelled by	3	screws	1	screw
Speed when light.......	15	knots	5.3	knots
Speed "awash"	14	knots	4.73	knots
Speed when submerged..	8	knots	4	knots
Time to submerge completely from light condition	1	minute	16	minutes
Number of torpedo tubes	2		1	
Provision for escape of crew		some		none

Upon the basis of total submerged displacement—$150,000 being the contract price for the "Plunger" as well as the purchase price of the "Holland"—the "Plunger" was to cost $1,083 a ton, while the "Holland" actually cost not less than $2,027 a ton. As the table shows, the government paid a very tidy figure for "the inventor's most advanced ideas." In further proof of what this means, Secretary Long, under date of February 28, 1899, sent the Hon. Eugene Hale the following illuminating statement:

"Although smaller, the 'Holland' is less complex in her machinery and is constructed according to plans involving *less expense* than those upon which the 'Plunger' was built."

Rear-Admiral George W. Melville, U.S.N., has testified that $70,000 was a reasonable maximum cost for the "Holland"; and Mr. Francis T. Bowles—now president of the Fore River Shipbuilding Co.—when Chief Constructor of the United States Navy, stated: "My calculations show that a reasonable cost, with a handsome profit to the contractor for the boats now building ('Adder' and class of 122 tons submerged displacement) would be $89,459." The "Adder" class cost the government $170,000 each. It will thus be seen that the government has paid more than double the cost—plus a handsome profit—for the "Holland" and the boats of the "Adder" class, and that despite the fact that the money provided for the "Plunger" had afforded facilities for the development of the inventions incorporated in the succeeding boats. This acknowledgment of indebtedness to governmental bounty has been subscribed to no less than three times by the John P. Holland Torpedo Boat Company under seal, and the specific language of that admission reads as follows and bears upon the question of possible purchase by the government of the Holland Company's patent rights:

"In assessing the value of such rights said board shall take into consideration not only the value of the property but also the *fact* that the United States has afforded facilities for the development of the inventions covered by such rights by the appropriation of money to build the 'Plunger'."

In March of 1899, eight months before the "Holland" was tried by the Naval Board, her promoters secured the passage of a bill providing for the construction of two boats similar to the "Holland." In June of the following year, further legislation for five boats of the "Holland" type was similarly obtained, and by the language of the bill it was made mandatory that the Secretary of the Navy should contract for those vessels; and it was by reason of the laws of 1899 and 1900 that the "Holland" was purchased and seven other boats of the "Adder" class ordered, one of which, the "Plunger," was to take the place of the original boat of that name which had been abandoned unfinished. By the terms of the contracts these seven new boats were to be delivered within periods varying from eight to eleven months from the dates of their contracts—making a total aggregate of working time amounting to sixty-six months. In excess of this contractional period, there was an aggregate delay in delivery of all of these boats of one hundred and fifty-five months, representing penalties incurred amounting to nearly $310,000—not one cent of which was ever imposed or collected, so indulgent was the government in this matter. By far the longest delays occurred were those due to the final adjustment of the vessels in preparation for their official trials—and in most cases these delays covered periods of eighteen months or more after the government had made four-fifths of the payments due under the contracts. Mr. Isaac Rice, president of the company, has explained in a fashion how some of this delay was incurred; and he tells us, in substance, that even before his company had secured the contracts for the seven boats in 1900 they began to build the "Fulton" as an experimental craft. This is what he has said further:

"The 'Fulton' was an experiment, and as changes have proved themselves on her from time to time we took things out and put other things in and gave the government the benefit of that without one cent of charge."

If the "Fulton" was an experiment, then the entire group of boats of the "Adder" class contracted for in 1900 were also experiments for which the government was to pay; and the prime object in building the "Fulton" was to find out possible errors by building first one boat instead of multiplying the mistakes simultaneously on seven. It is perfectly plain that up to the time the John P. Holland Torpedo Boat Company secured the contracts for the boats in 1900 it had no sufficient guarantee of experience to warrant the claims and promises advanced under the terms of those contracts. Mr. Rice has further said in his testimony before Congress, in 1902:

"The performance of the 'Fulton' was something beyond anything that was ever expected."

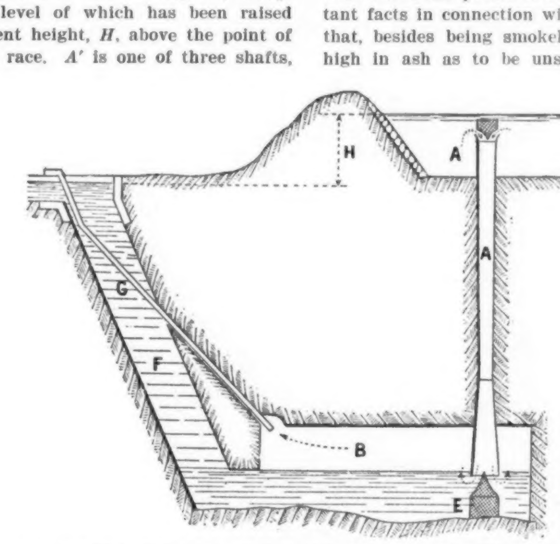
As the record of the "Fulton" shows her to have fallen behind the contract requirements of the "Adder" and class, and remembering that Mr. Lewis Nixon, on behalf of the Holland Company—after the "Fulton" had been "proved" by her builders—asked for a material reduction in the speed requirements of the boats of the "Adder" class then building, one can reasonably ask what *did* the Holland Company expect to produce when it made its promises in 1900?

It will thus be seen that the United States government from the very beginning was footing the bill for the Holland Company's experiments, and further that the national purse was being taxed very heavily to provide a profit for the John P. Holland Torpedo Boat Company.

(To be continued.)

A NEW METHOD OF OBTAINING MOTIVE POWER.

A NEW method of obtaining motive power at small cost has been devised by an American inventor, who drives motors by air which has been compressed by the action of a fall of water. In the diagram, *A* represents a pond, the level of which has been raised by a dam to a sufficient height, *H*, above the point of emergence of the tail race. *A'* is one of three shafts,



A NEW METHOD OF OBTAINING MOTIVE POWER.

about five feet in diameter, sunk from the bottom of the pond to a depth of 330 feet and terminating in a subterranean chamber, *B*, of a capacity of 70,000 cubic feet.

In accordance with a well-known principle, which is illustrated in the water blower and the mercury air pump, the water, in falling down the shafts, carries with it air, which accumulates in the underground chamber. The separation of the air from the water is accelerated by the impact of the descending stream on a conical mass of concrete *E* at the bottom of each shaft.

The air in the upper part of the chamber attains a pressure of 7¾ atmospheres. The compressed air is conducted to the motors by the pipe *G*, while the water escapes through the tail race *E*, the free surface, after emergence from the ground, lying about 65 feet lower than the level of the water in the pond *A*.

Five thousand horse-power, being 82 per cent of the theoretical power computed from the rate of flow and the difference of level *H*, is developed in the motors.

The cost of installation is large, but the cost of maintenance is very small.

THE BURNING OF COAL WITHOUT SMOKE.*

By D. T. RANDALL.

THE prevention of objectionable smoke in the manufacturing and business centers of large cities is a problem that cannot be easily solved. At present no city in which a considerable quantity of bituminous coal is burned is free from smoke. The cities of the East have avoided this problem by a general use of the smaller size of anthracite coal. For this reason it is not surprising that the greatest improvement in the methods of burning bituminous coal has been made in the Central and Western States.

Stoves, ranges, house-heating boilers, and hot-air furnaces are as a rule intended for the use of anthracite coal or coke. Whenever bituminous coal is burned in such furnaces all the principles of combustion are violated and smoke results. The supply of anthracite coal is limited, and except for domestic purposes such coal is little used outside of the territory adjacent to the mines. The larger cities of the Eastern States, which consume practically all the available supply of the smaller sizes of anthracite coal for power and heating purposes, now find it necessary to supplement this fuel with a considerable tonnage of bituminous coal. Except the power generated by waterfalls, nearly all the heat and power used in the United States are obtained from the burning of coal. It is evident, then, that for the most part this country must depend on its bituminous coal for manufacturing, railroad, and power-plant purposes. This means that we must improve our usual methods of burning bituminous coal or continue to suffer from the loss in economy and smoke resulting from imperfect combustion.

There are three general methods of utilizing coal—in steam boiler and other furnaces, in gas-producer plants, and in by-product coke plants. Of these, the last two methods are readily operated to produce heat or power without smoke, but at the present time such plants are not numerous and consume only a small portion of the coal that is used in this country. It has been demonstrated at the fuel-testing plants of the Geological Survey that bituminous coal of all grades can be burned in a gas producer without smoke, generating a gas which when used in a gas engine furnishes power with much greater economy than is usual in steam plants. With good grades of coal mined in the Eastern States a horse-power can be generated with about one pound of coal. One of the most important facts in connection with the gas-producer plant is that, besides being smokeless, it will utilize coals so high in ash as to be unsuitable for boiler furnaces. The lignite coals of the West are also particularly well adapted for use in the producer though they are considered much inferior to bituminous coal for boiler furnaces. About fifty producer plants are now in operation in the United States burning bituminous coal. Interest in such plants is increasing, and many new ones are being planned, ranging in capacity from 500 to 10,000 horse-power each.

That the coal supply is being wasted in many ways is a fact that has been frequently brought to the attention of the public. One waste results from the ordinary methods of manufacturing coke, in which all of the gas from the coal is allowed to escape into the air. This loss has led to the installation of a few by-product coke plants in which coke is made and the resulting gas is piped to points where fuel is needed and there consumed. Other valuable products from the distillation of coal are also obtained. These plants, furnishing both coke and gas as fuel, constitute a considerable factor in the prevention of smoke in the cities near which they are located, as both fuels are burned readily without smoke for domestic purposes and for manufacturing industries requiring heat or power. The convenience and cleanliness of these fuels will probably lead to an increase of their production and use.

It is reported that there are thirty by-product coke plants in this country, with a total of more than 3,000 ovens, using nearly 20,000 tons of coal a day. It is estimated that these plants manufacture daily more than 50,000,000 cubic feet of gas.

* Abstract from a bulletin of the United States Geological Survey.

In Congress, on February 10, Representative McKinley, of Illinois, introduced a bill for the erection of a monument in the city of Washington to the memory of John Ericsson. The bill provides for the appointment of a commission to look after the erection of the statue; also for an appropriation of fifty thousand dollars.

ELEMENTS OF ELECTRICAL ENGINEERING.—XIII

PRINCIPLES OF ALTERNATING CURRENTS.

BY A. E. WATSON E.E., PH.D., ASSISTANT PROFESSOR OF PHYSICS IN BROWN UNIVERSITY

Continued from Supplement No. 1678, page 141.

THE natural condition of currents generated in dynamos is alternating in direction. A common illustration of this principle is supplied by a telephone magneto. One end of the armature winding is attached directly to the iron core, while the other end terminates in an insulated pin, resting upon a contact spring. In the absence, therefore, of any special device to rectify or "commutate" the currents, they pass into the external circuit in the very directions in which they are generated. An ordinary induction coil, too, supplies alternating currents from its secondary, but since the "break" of the primary circuit is much more sudden than the "make," the

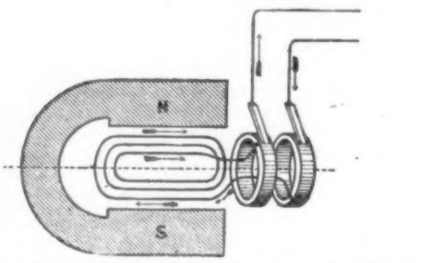


Fig. 49.—Simple Alternate Current Generator (Single Phase).

electro-motive forces induced in the two directions are not equal; that produced by the break is ordinarily much the greater.

Machines of more pretentious dimensions than "magnetos" would ordinarily have both terminals of the armature winding insulated, and brought out to two rings, on which fixed brushes may rest, and serve to continue the path to the exterior circuit. Fig. 49 represents this idea in most elementary form. In this a single coil of wire, presumably wound on a Siemens H, or shuttle, core, rotates between the poles of a horse-shoe magnet. The functions of the rings and brushes are also clearly seen. Probably no one is now living who entertains the old notion that the friction of brushes produces any electricity. Of course they merely provide continuity to the circuit. Since these rings have no commutation properties as have the separate segments of a commutator, they are usually denoted as collector-rings, or for short, collectors.

It is not important that the coil should do the moving; for this wire can be stationary, with the line attached to convenient binding posts, and the magnet be the revolving member. In case the latter be an electro-magnet, rather than one of the permanent order as shown in the cut, its coils would need to terminate in rings through which the direct current for excitation could be led. Indeed, revolving field-magnets of multipolar design possess some qualifications not found in the other construction, and may now be said to be the standard form. In the figure, in as far as the coil is concerned, the arrows point correctly; the upper part of the winding is supposed to be moving toward the observer, and an application of Fleming's right-hand rule will give the directions as shown. Al-

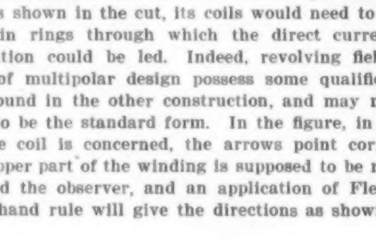


Fig. 50.—Curve Representing Alternating Current or Electromotive Force.

ways will the principle hold, that those conductors under the north pole will experience induction in one direction, and those under the south pole in the opposite direction. At the instant taken, the current will pass on to the line, and return from the line in the indicated direction, but half a period later, when the bottom wires have reached the top position, they, in turn, will have current induced in the direction to the right, and since that terminal is connected to the other ring, the arrows in the external circuit would need be reversed.

More detailed descriptions of the actual construction of the generators will be given in a subsequent chapter, but it is appropriate at this point to suggest that only the serious reader will be able to conceive and arrange the various factors concerned in a treatment of the properties and performances of alternating currents. Simple arithmetical methods of computation are insufficient, and ordinary expressions fail to convey the whole idea. A new language must be learned, unexpected factors admitted and analyzed, algebraic or geometric processes adopted, and graphical representations devised. Definiteness is further hampered by the knowledge that not one of the fundamental qualities has visible existence, and though treated by slow logic, they in reality may move with frightful rapidity. A complete theory of alternating current phenomena is replete with most extended mathematical processes and physical conceptions but this article will be limited to the barest suggestions compatible with accuracy.

When a given coil of an armature winding is midway between the poles of a field magnet, no lines of force are being cut, or in other words, there is no change in the number of lines of force threading through the coil, and therefore no electromotive force is being induced; as the coil approaches one pole, change does take place, and under the center of a pole, the change is most rapid; then when the coil has made half a turn, induction again ceases; during the second half of a revolution, the coil is under the influence of the other pole, and experiences an induction just equal to the former, but in the opposite direction. It is certain that one direction of the electromotive force is just as useful as the other. How can such a change of values be represented, both graphically and numerically? The performance of a simple coil rotating in an elementary two-pole field can be analyzed into four stages, constituting a complete "cycle," i. e., the rise of the electromotive force from its zero to its full value, under one pole, its decadence to zero again, its rise to an equal maximum value in the other direction, and its return to the original zero condition. Further revolutions would be mere repetitions of this cycle. In a two-pole field magnet the number of cycles in a second is equal to the number of revolutions per second; in a multipolar field magnet, the same cycles of changes would be produced in part of a revolution, i. e., in the time required for a given coil to pass from one pole to the next one of the same kind.

The trigonometric curve of "sines" shown in Fig. 50 is at once available for depicting these changes. A circle of any convenient diameter may be drawn, and the circumference divided into equal parts, the principal divisions of course being 0, 90, 180, and 270 degrees. Likewise a straight line through the center, of any convenient length, may be divided into 360 parts, and vertical lines drawn through as many points as were in the circle. By projecting successive points in the latter upon the corresponding vertical lines, intersections will be formed, and a curve through them will be in the shape represented. That portion of the curve above the axis is called the positive branch, and that below, the negative branch. In actual machines, the real instantaneous values of the electromotive force do not form such a uniform path as that shown, but the aim is so to shape the coils and pole pieces as to approach it as near as consistent with good mechanical construction.

The effective value of an alternating electromotive force for current evidently cannot be represented by the maximum vertical line, or ordinate, of the curve, for that value is held but for an instant; neither can the zero value be taken, for that is an even shorter instant, and there is plain proof that the alternating current really exists. A mean must be taken somewhere between the zero and the maximum, with extra weight given to the latter in consequence of its longer prevalence. A principle in physics gives the clue; it states that the energy of a wave motion is proportional to the square of the amplitude. The straight line of 360 degrees can be conceived as extended to a length of several feet, and the sine curve produced by the vibrations of a musical chord, with a node in the center. Each part of the string would have its own amplitude and the energy of the vibration would be the square root of the mean of all these squares. To find it simply, one has only to consider what is the mean, or average square between the extremes—zero-square and the maximum or one-square. Plainly it is one-half square, and an area of half a unit square, or 0.5, has one side of that square 0.707 in value, for 0.707 squared equals 0.5. From another point of view, half way between 0 and 90 degrees is 45 degrees; the sine of 0 degrees is 0, and the sine of 90 degrees is 1; but the sine of 45 degrees is 0.707. The calculus also serves as a means of deriving this value, but the suggestion already given will suffice. The conclusion is that an alternating electromotive force or current has an effective value of 0.707 of the maximum; that is, if an alternating electromotive force was periodically varying between 0 and 100 volts, it would produce the same deflection on an appropriate voltmeter as 70.7 volts with direct current. Or, if 1,000 volts alternating were being generated in a dynamo as indicated by the voltmeter, the potential really has a momentary maximum value of 1,000 divided by 0.707 equals 1,414 volts. Insulation tests with alternating currents are therefore much more rigorous than with the same nominal value of direct current pressure. Not only does the maximum exceed that of the latter, but being exerted first in one direction, then in the other, greater disruptive stress is exerted.

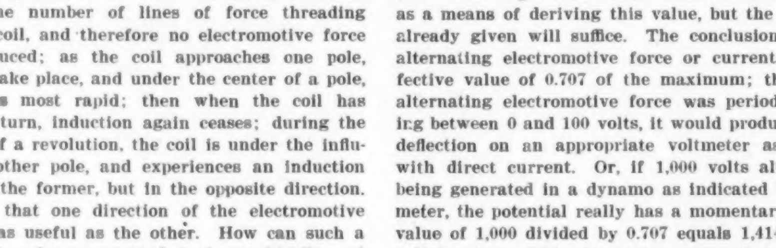


Fig. 51.—Triangles Illustrating Resistance and Electromotive Force in an Alternating Current Inclosed Arc Lamp.

In the case of direct currents, the power in watts is found by simply multiplying together the number of volts and amperes. In some kinds of circuits this is the true method also, with alternating currents; in other kinds it is not even approximate, and in extreme cases quite misleading. These two kinds of circuits are technically designated as "non-inductive" and "inductive," the former being typified by an incandescent lamp or other heat load, and the latter by an aggregation of iron and copper as might be found in an electric motor. Whenever an electric current changes in strength, it changes the amount of magnetism contained within that circuit. Magnetism is conveniently estimated in lines of force, and there is a law of Faraday's as inexorable as that of gravitation, that whenever the number of lines of force in a circuit changes, an electromotive force is produced. It is important to recognize in what direction this self-induced electromotive force acts, and when it has its maximum and zero values. If the curve shown in Fig. 50 be regarded as showing the number of amperes in a given circuit, it will be seen that at the zero and 180 degree points, the rate of change is the greatest, for just before either of those values the current was flowing in one direction, and just afterward it was flowing in the opposite direction; any iron that might have been within a coil then experienced a reversal of polarity

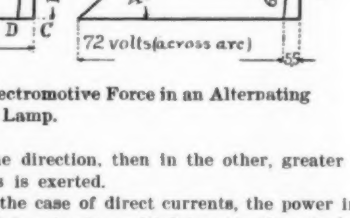


Fig. 52.—Current Curves.

an extreme change. At the 90 and 270 deg. points, the current momentarily became steady, and all changes in strength of magnetism plainly ceased. The maximum electromotive force of self-induction was then induced at the 0 and 180 deg. points of the current curve, and none whatever at the 90 and 270 deg. points. If a second sine curve was drawn on top of the first, the new one, to show the instantaneous values of the self-induction, its maxima would be just over or under the zero values of the current curve. In other words, it would be displaced one-quarter period, or 90 deg., from the current curve. Self-induction is a factor in electrical circuits analogous to inertia in mechanics; it exerts a force in the direction always to oppose a change; the whole designation, the counter electromotive force of self-induction, is rather cumbersome, and the expression, "reactance voltage," is a common substitute. To overcome the reactance of a circuit of course additional voltage over that required for the ohmic resistance is needed, but the exact

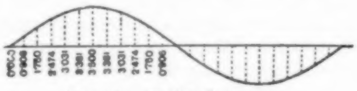


Fig. 53.—E. M. F Curve.

amount is not the arithmetical sum, for the maximum values of the two forces need to be exerted at different instants. That to overcome the ohmic resistance is directly proportional to the current, having its zero value coincident with the instant of no current, and its maximum, when the current is to be a maximum. That to overcome the reactance, as already explained, has its maximum value when the current is just at zero value, i. e., a quarter period, or 90 deg., different in time period, or "phase." Now a convenient way to represent 90 deg. is by a right-angled triangle. If a base line be drawn, in length proportionate to the resistance of the circuit, and at one end, say the right, a perpendicular be erected, proportionate to the reactance, the hypotenuse that may be drawn will represent the geometrical sum of the two factors, and actually measure the total "impedance" to the flow of current. The acute angle at the left will represent the amount by which the current "lags" behind the electromotive force; the amount is of course an interval of time, but graphically represented by the time it takes the armature coil to pass over a given angle. If the resistance of a circuit is great as compared with its reactance, as in the case of an incandescent lamp, the vertical line disappears, and the resistance and impedance become identical, and the angle of lag is zero. If the circuit is a reactive, or "kicking" coil, or the primary of a transformer, the resistance may be almost negligible, and the base line disappear, while the vertical line may closely represent the impedance; the angle of lag then approaches 90 deg. Even if the resistance became actually zero, it is seen that the angle of lag can never exceed 90 deg. The circuit that has both resistance and reactance is represented by intermediate lines. For an illustration take the case of a modern inclosed arc lamp, such as was shown in Fig. 17 of Chapter IV., adapted for use on a circuit of 104 volts and 60 cycles, normal current being 5.5 amperes, with 72 volts difference of potential across the arc itself. The reactive coil in top of lamp is to take care of the difference between 104 and 72, but the arith-

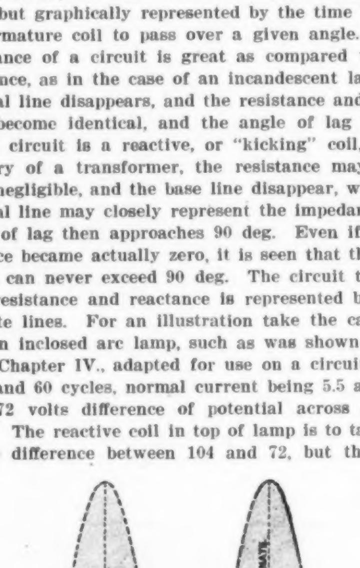


Fig. 54.—Power Curves. No lag of Current.

metical difference of 32 is not correct; the right-angled triangle must be drawn as shown in Fig. 51. The sides can as well represent volts as ohms, so both cases are given. Seventy-two divided by 5.5 equals 13.1, or the number of ohms resistance of the arc itself. In the copper windings of the reactive and regulating coils there may be a resistance of 1 ohm more; therefore, in all, the base line of the triangle will be 14.1 units long, to represent the ohmic resistance, or 77.5 units to represent the volts. Erect a perpendicular at the right-hand end, and with a radius of 104 divided by 55 equals 19, and a center at the other end of line, swing an arc until the vertical is intersected; now draw a straight line connecting the two points. The corners of the triangle may now be conveniently lettered *A*, *B*, and *C*. Measuring off *BC*, it is found to consist of 12.7 approximately, and multiplying this number by 5.5, the actual number of volts exerted by the reactance of the circuit is found to be 69.4, that is measured around the corner, 77.5 plus 69.4 equals 104. The angle *BAC* represents the amount of lag of the current in the lamp as a whole, while the angle *BDC* is that in the kicking coil alone—closely 90 deg. Those familiar with geometry will at once recognize that *AB* is merely the square root of the sum of *AC* and *BC* squared, and that with any two of these values given the third can readily be found. Likewise, by trigonometric principles *AB* divided by *AC* is merely the cosine of the included angle, but because that term may not be entirely suggestive to many artisans, the equivalent expression "power-factor" has been substituted. Its numerical value is always less than unity.

This long digression has been merely for the purpose of providing means for estimating the power in an alternating current circuit. Instead of using the maximum values of electromotive force and current, it is obviously more convenient to utilize the effective values indicated on the measuring instruments. By the aid of the power factor the component of the mean or effective current that is in existence when the volts are at their mean value can readily be found. Hence by multiplying the number of volts by the number of amperes and by the power-factor, the correct power in watts is obtained. If there is no lag of current, the power-factor is unity and the ordinary product of the volts and amperes results, as with direct currents. If the angle of lag is very large, the power-factor is a very small fraction, and while the instruments may indicate normal readings, the actual power utilized or developed by the dynamo may be incredibly small. With inductive circuits, *volts* × *amperes* and *watts* are quite two different things. In the case of the arc lamp, the volts × amperes equals 104 × 5.5 equals 572; but the power-factor equals 77.6 divided by 104 equals 0.746, and 572 × 0.746 equals 428, the true number of watts consumed.

Though logical, and with correct numerical results, this reasoning may have been a little tedious, and by its lack of material embodiment, may have failed to be as convincing as desirable. This defect is unavoidable, and if electricity itself is unknown and invisible, it is not strange that conventional and indirect methods of representation and treatment are involved. Still graphical diagrams can represent some elements of the truth, and this is conspicuously the case with the power measurements. Diagrams will be given to illustrate three typical cases—one in which there is no lag of the current, a case corresponding to an incandescent lamp load; a second, in which the current lags by 45 deg., closely typified by the arc lamp just explained; and a third, in which the current lags by quite the theoretical limit, 90 deg.; a close approximation in practice to the last is the instance of an ordinary transformer primary, when the secondary circuit is open. As no particular values of current and electromotive force are needed to illustrate the principle, the ones shown have maximum values of 7 amperes and 3.5 volts, respectively. Any other numerical values would have served just as well. As far as the readings of the instruments are concerned, they would show these values multiplied by 0.707, or about 5 amperes and 2.5 volts. These component curves are shown in Figs. 52 and 53.

Fig. 54 illustrates the power actually in circuit when there is no lag of the current behind the electromotive force. The zero values of both curves occur at the same instant, likewise their maximum values, and the product of these two factors gives the true instantaneous power in watts. At 0 deg., the power is zero; at 90 deg. the product of the factors gives 24.5, the maximum value; at 180 deg. the power is again zero, and at 270 deg. again a maximum; although in this half of the cycle, both current and electromotive force are represented below the axis, and therefore negative, all that the negative sign means is a reversed direction, and current in one direction is as good as that in the other, and fully entitled to be regarded as of positive value. Also by the algebraic principle, that the product of two positive quantities is positive in sign, so the product of negative factors, too, gives the positive sign. The power in circuit is alternately 0 and 24.5 watts, and a wattmeter would indicate 0.5 of the maximum or 12.25 watts. A rectangle is shown in dot-and-dash lines, having a base *XX′* and height *YY′* of 12.25 units, embracing an area equal to that of the two shaded sine curves, meaning that a steady, or direct, current under such pressure as to represent 12.25 watts would do the identical work.

The source of the factor 0.5 is seen to result from the double multiplying of the number 0.707. The effective number of volts is that fraction of the maximum, and also the effective number of amperes is the same fraction of its maximum, therefore in taking the product to find the number of watts the product of 0.707 × 0.707 equals 0.5. Measuring instruments do not, however, show these maximum values, but if required are to be found by dividing the observed effective values by the fraction.

In Fig. 55 the zero value of the electromotive force was at a certain instant, but since that instant, the armature coil has had to turn through an angle of 45 deg., before the current was driven to its zero value; similarly the voltage wave reached its maximum and began to decrease in value before the current had attained its maximum, in the same direction. The zero values of the two curves do not therefore coincide, and since the product of the ordinates gives the instantaneous power, and with the algebraic principle that if either factor becomes zero, the product also becomes zero, there will now be four such instants, and at other times there will be products that result from

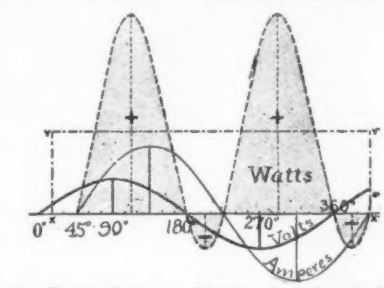


Fig. 55.—Power Curves. Current Lagging 45 Degrees.

the multiplication of factors with unlike signs. Thus at 45 deg., the electromotive force is something, but the current is zero, therefore their product is zero; the power curve then begins at that point. Until the 180 deg. point is reached, the E. M. F. and current waves are real and positive, so their product gives a positive area, with a maximum at 112.5 deg. At 180 deg. the E. M. F. becomes zero, and so, too, the power. Between this point and 225 deg. the current, however, remains positive, while the E. M. F. has become negative, hence their product, though real, is also negative. This is represented by an appropriate shaded area below the axis. Between 225 deg. and 360 deg. both factors are negative, therefore their product is positive and again drawn above the axis, while between 360 deg. and 405 deg. the E. M. F. is again positive, while the current remains negative, and the product is a second negative area. The real power expended in the circuit is the difference between these positive and negative areas. It is seen that the maximum value of the power is less than in the case shown in Fig. 53, and when the subtraction of the negative areas is made the equivalent rectangle actually sinks to the dimensions of *XX′YY′*—the height being only 8.66 units.

The general expression for the power in a circuit of this sort, in which the current is "out of step" with the voltage, is that the watts equal volts × amperes × cosine of angle of lag. In practice, this last expression conveys a rather unnatural sound to the wayfaring man, so the same thing under the designation "power factor" has been substituted. In this case, since the cosine of 45 deg. is 0.707, the multiplication of the real power, 12.25 watts, by this fraction gives 8.66 watts, as stated. Of course, electrical energy is ignorant of any of these ingenious methods of measurement, but the principle is convenient, in that it allows the formula to be used backward; and from the comparison of the true watts as measured with a wattmeter, and the volts and amperes as measured with their appropriate instruments, the power factor of any given circuit can readily be ascertained.

By the expression that the electromotive force is positive while the current is negative, is merely meant that though the former has actually changed in direction, it has not yet succeeded in reversing the flow of the current. The case of trying to reverse the direction of rotation of a flywheel is analogous; though

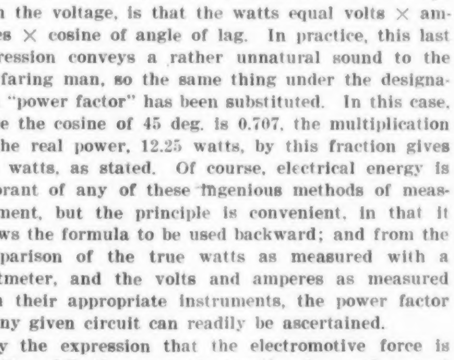


Fig. 56.—Power Curves. Current Lagging 90 Degrees.

force may be exerted, the contrary motion may continue for an appreciable time. The example of the lag of a result behind its cause is one not unknown in other lines of nature, notably in the conduction of heat. The coldest season in winter is by no means coincident with the shortest days, but lags by some two months; also, while the sun is above the horizon longest in June, the most sultry days do not occur until August. Neither is twelve o'clock the hottest instant of the day, but that lags until about two o'clock, while the coldest part of the night awaits until nearly sunrise.

Fig. 56 shows the third, and is a very interesting case; it is almost self-explanatory. There are the four zero values of the power per cycle, but the positive and negative areas are equal. Although ammeter and voltmeter may still indicate full values, a wattmeter would show zero, and no power would be required to

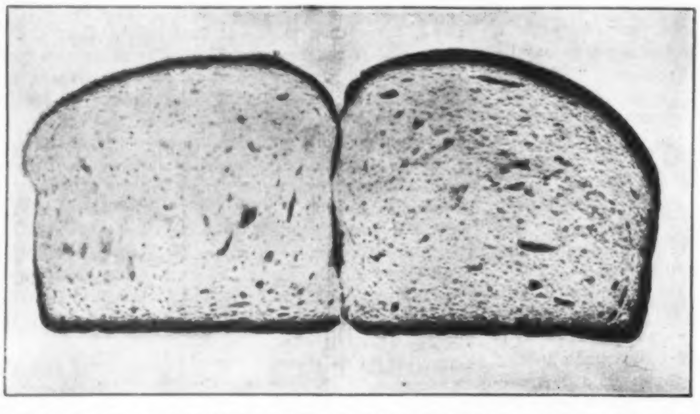
drive the dynamo. It is true that at one instant, the dynamo does supply power, but at the next it receives it back again from the particular piece of apparatus in which this 90 deg. lag is produced. It is the case of a pendulum swinging to and fro; force is exerted in falling to its lowest position, but all is needed to drive it to its other extreme position, where for an instant the energy is all potential, being stored in the stationary weight, then when moving most rapidly in its lowest position, its energy is that of motion, i. e., in the kinetic form; the intervals between these two positions are one-quarter of a complete period, or 90 deg. So with the electric current, at one instant, there is the maximum potential energy in volts, but no current; one-quarter period later, there is the moving current, but no voltage. No work can be done by the swinging pendulum; indeed, it requires the additional force of the spring or weight to keep it moving against its frictional resistance. So the current that lags by one-quarter period carries no useful energy, but demands just enough voltage to overcome the meager ohmic resistance of the circuit. With this introduction to some of the peculiarities of alternating currents, considerable progress may be made by the reader in an understanding and appreciation of the practical working of a large variety of apparatus. Further theory, with simple means of expressing numerical relations, will be reserved until the actual application actually arises. The fourteenth chapter will treat of alternating current generators.

A NEW KIND OF WHEAT.

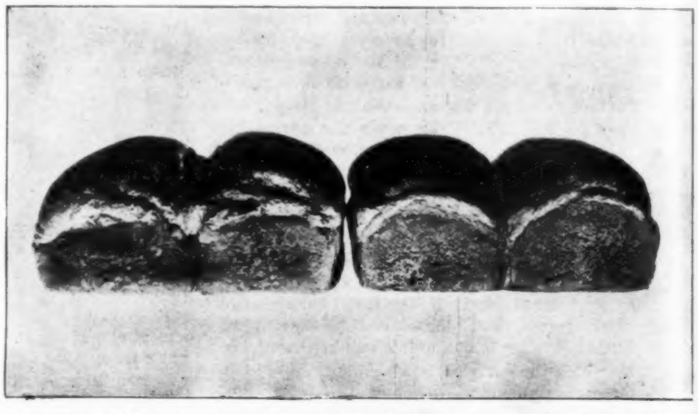
THE VIRTUES OF DURUM.

BY CHARLES CRISTADORO.

Varieties of hard wheats have from time to time been introduced into this country from Russia, Algeria, and Chile, but they have never become popular in the past because of the absence of a ready market for them. These wheats, better known, perhaps, under the rather restricted name of "macaroni wheats," belong to the class designated "triticum durum" because of their great hardness; a quality that gives them peculiar resisting powers to the usual wheat-pests.



FRESHLY CUT DURUM AND SPRING WHEAT BREAD SIDE BY SIDE. DURUM LOAF ON LEFT.



TWO LOAVES EACH OF DURUM AND SPRING WHEAT BREAD—A LATER BAKING. DURUM LOAF ON LEFT.

In characteristics, "durum" wheats differ quite markedly from the hard winter wheats of this country. They grow rather tall and have stems that are either pithy, or more or less hollow. In general, the leaves are broad and smooth, of a peculiar whitish green color, and possessing a very hard cuticle. The heads are comparatively slender, compactly formed, sometimes very short, with the longest beards known among wheats. The spikelets are two to four grained. The outer chaff is noticeably keeled, while the inner is rather compressed, and narrowly arched in the back. The grains are hard, glassy, and of a translucent yellowish white color. In size they are large. The general appearance is like that of the barleys, although many marked points of difference exist.

As has already been suggested, durum wheats are but slightly susceptible to damage by insects and fungus pests, although black stem-rust attacks them badly at times. Their only undesirable feature is a tendency to deteriorate rapidly when grown under unfavorable circumstances.

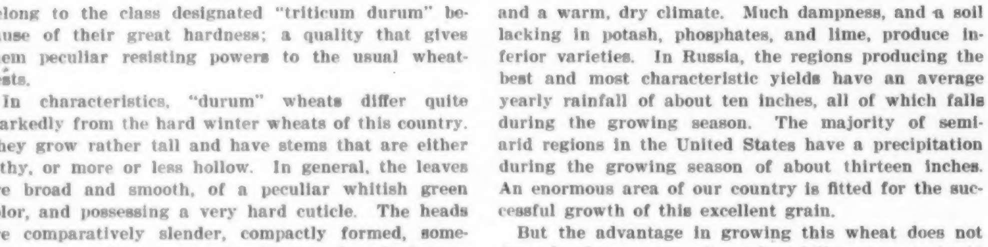
The conditions best suited to the growth of this variety are an alkaline soil rich in nitrogenous matter, and a warm, dry climate. Much dampness, and a soil lacking in potash, phosphates, and lime, produce inferior varieties. In Russia, the regions producing the best and most characteristic yields have an average yearly rainfall of about ten inches, all of which falls during the growing season. The majority of semi-arid regions in the United States have a precipitation during the growing season of about thirteen inches. An enormous area of our country is fitted for the successful growth of this excellent grain.

But the advantage in growing this wheat does not depend alone upon its adaptability to semi-arid grounds. It is also highly desirable on account of its high gluten content, the basis upon which the relative values of wheats are founded. Good bread cannot be made in the absence of gluten.

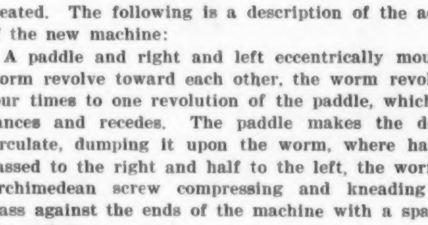
The Kubanka durum wheat of Russia yields 15 per cent of gluten when grown on its native soil. When grown in this country it yields from 18 to 20 per cent of this compound. With selective planting there is no reason why 25 or even 30 per cent could not be reached. The one possible objection to durum bread, its color, has been overcome by the introduction of kneading machinery that bleaches the dough by means of air. Air is an efficient and harmless bleaching agent; in fact, thoroughly aerated bread is much lighter, and is more wholesome than that which has not been so treated. The following is a description of the action of the new machine:

A paddle and right and left eccentrically mounted worm revolve toward each other, the worm revolving four times to one revolution of the paddle, which advances and recedes. The paddle makes the dough circulate, dumping it upon the worm, where half is passed to the right and half to the left, the worm or Archimedean screw compressing and kneading the mass against the ends of the machine with a spatula-like action.

When the worm dips into the dough and divides it, a partial vacuum is created and the air rushes into the opening, where it is entrapped. The charge of air works its way under the paddle where it becomes enmeshed and disseminated through the dough in the form of numberless small air cells. As soon as the worm compresses the paste against the ends of the machine these air cells are expressed. Upon the com-



SAMPLES OF VARIETIES OF DURUM WHEAT.



DROUGHT-RESISTING DURUM WHEATS.

1. Kubanka. 2. Nicaragua. 3. Velvet Don. 4. Black Don. 5. Wild goose.

A NEW KIND OF WHEAT.

pletion of the cycle a fresh charge of air is introduced; and so on until the desired result is attained. The yellow durum dough becomes white, and as a result a beautiful, light, snowy, crusty, sweet and wonderfully nutritious loaf of bread results.

Besides possessing such a high gluten, muscle-making content, durum flour is heavily charged with sucrose, vegetable sugar; so that durum bread is sweet to the taste even in the absence of any cane sugar whatsoever.

The following comparison between lean beef and the bread made from this new flour is instructive:

In one hundred ounces there are:

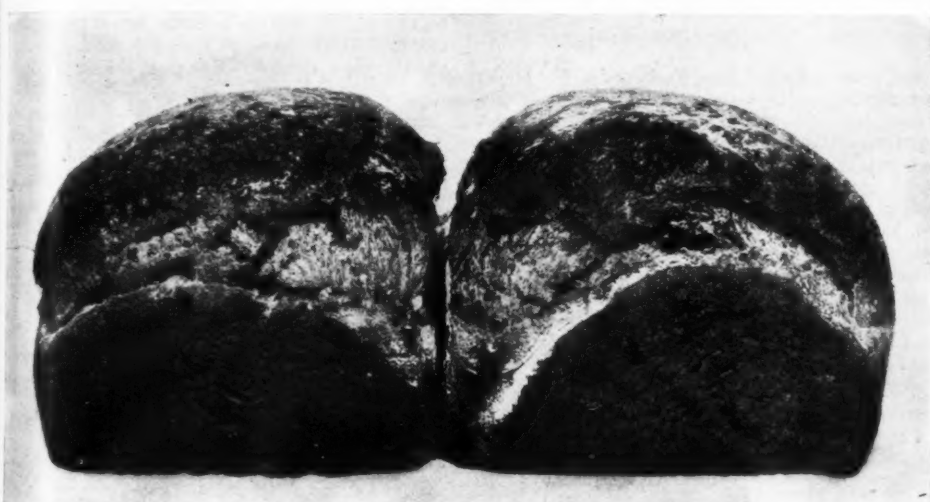
	Water.	Muscle Makers.	Heat Makers, Fat or Starch.
Beef—lean of roast or steak..	77 oz.	18 oz.	5 oz.
Durum bread	35 oz.	13 oz.	52 oz.

These figures show that apart from the privation of being without meat, one could live on this bread alone, since it contains a sufficient quantity of the muscle forming constituents, together with a large percentage of the heat forming compounds which are entirely lacking in lean meat.—Abstracted from Bulletin 70, Bureau of Plant Industry, Department of Agriculture.

GHARNOVKA WHEAT AT THE NEW MEXICO EXPERIMENT STATION.

DEFECTS OF THE FARMAN TYPE OF AEROPLANE.

The principal difficulty in the aeroplane of the Farman type is the over-heating of the engine. The limitations of weight were such that there was insufficient cooling capacity. The engines carry a very small volume of water, and there is also a very poor radiating surface to keep the water cool. As a result the engine runs for a few minutes, then gets hot and slows down, and the aeroplane necessarily comes down to the ground. That is the reason why Farman is never quite certain when he will come to the ground. Another point which will arise in the course of time, when aeroplanes are capable of doing journeys of 100 or 200 miles, is the personal element, the strain in operating one of these machines being tremendous. That is not the case with the Farman engine, because there is no carbureter, throttle, or variation of ignition, everything being set and fixed, so that the aeronaut can devote his attention to balancing and steering; but in an aeroplane of the Wright type there is, first, the two kinds of steering—the vertical and the horizontal. The balancing has to be watched the whole time; then the throttle of the engine has to be looked after to adjust the variation of speed, in addition to the adjustment of the mixture for carburetion, the lubrication, and many other things. The Wrights state that it was perfectly possible a machine would be built which would be able to run 150 or 200 miles before it would be possible to find an operator for it.



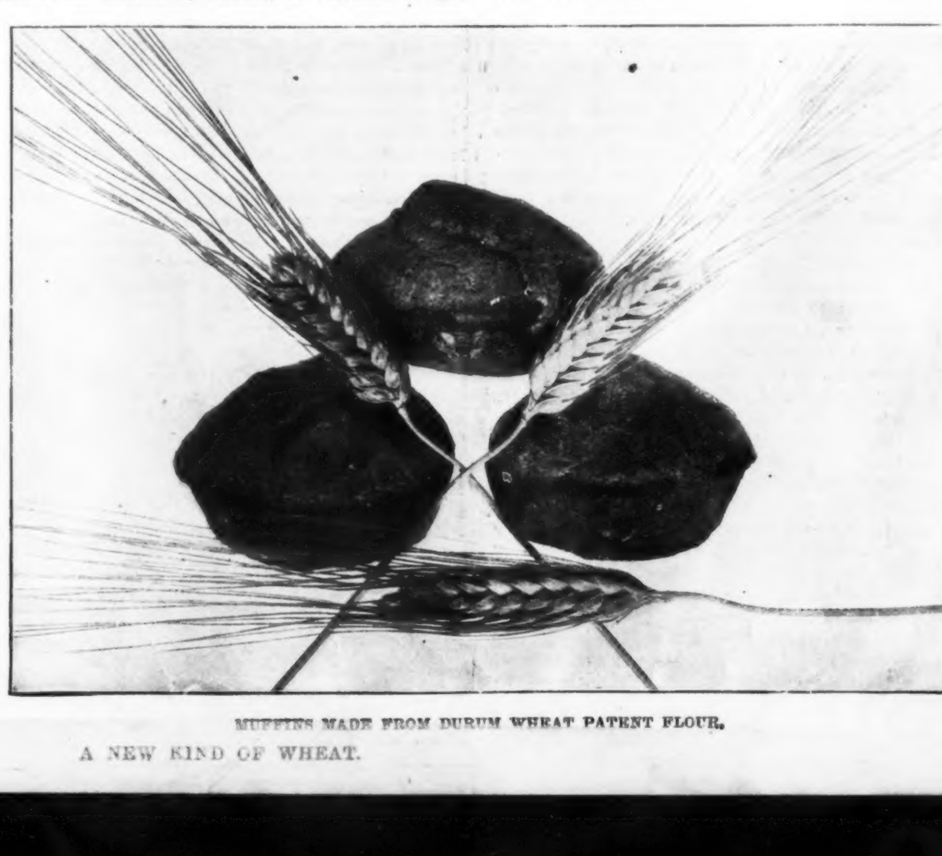
LOAVES OF BREAD, ONE MADE FROM DURUM WHEAT PATENT FLOUR, THE OTHER FROM BEST QUALITY NORTHWESTERN HARD SPRING WHEAT PATENT FLOUR.

These loaves were made at the same time, by the same bakery, and under the same conditions, the same kinds (except flour) and same proportional amounts of ingredients being used in each.

Within recent years many windmills have been erected in Denmark for various purposes, but principally for the production of electrical energy. The special studies of the efficiency of windmills which Danish engineers have been making have led to the unexpected and surprising conclusion that the old-fashioned windmill with four large sails is a far more efficient air engine than any of the modern many-bladed devices. The experiments that have been made in Denmark prove that four surfaces are better than either a larger or a smaller number. A smaller number fails to utilize the whole force of the wind and a larger number produces deflections of the air current that diminish the efficiency. To give an idea of the power that can be obtained from windmills it may be stated that a windmill having an aggregate sail area of 500 square feet can develop 8 horse-power with a wind of 20 feet per second, and 16 horse-power with a wind of 26 feet per second. These wind velocities are very moderate and of common occurrence. They correspond approximately to numbers 4 and 5 of Beaufort's scale in which the most violent winds are numbered 11 and 12.

DROUGHT-RESISTING DURUM WHEATS.

1. Polish. 2. Medeah. 3. Missogen. 4. No. 1774 S. P. I.



MUFFINS MADE FROM DURUM WHEAT PATENT FLOUR.

A NEW KIND OF WHEAT.

THE BASIS FOR A NEW GEOLOGY.—I.

RAISED BEACHES AND THEIR CAUSE.

BY H. W. PEARSON.

IT has long been known to those who have paid attention to the superficial features of the earth's crust, that on the lesser elevations of all continents there exist certain phenomena in the way of raised beaches or abandoned shore lines, which testify in the strongest manner that during some very recent geologic period, these lands have been deeply submerged beneath the waters of some long-enduring lake or sea.

The convincing nature of the evidence as to submergence, to which these ancient coast lines bear witness, has long been recognized and accepted by geologists; but if explanation be requested as to the manner in which these terraces, once necessarily near the water's level, have acquired their present considerable altitudes above the sea level, no decisive or satisfactory reply can be given. The subject still remains one of the most perplexing problems of science.

It may now be stated that it is the purpose of the writer, in the discussion to follow, to make what he hopes may be a serious contribution toward the final settlement of this difficult question. It seems, however, that previous to the presentation of his own results, it is indispensably necessary to examine the methods and processes used in earlier labors, as the subject seems now obscured by such an array of widely diverse theories and deductions which have from time to time been advanced by previous students, that some clearing of the ground is much to be desired.

The theories and beliefs now obtaining in this matter of the raised beaches, are in many cases not only inconsistent with the requirements of physics, but are often in opposition with each other, and especially do they come in conflict with the principles and results to be advocated in this paper. It is therefore necessary that examination be made in all cases where discordance in opinion may appear, that the inquirer may be in position to discriminate as to the merits of the several methods, and as to the relative value of the final conclusions.

EUROPE.

The first extended study of these terraces seems to have been undertaken by Robert Chambers ("Ancient Sea Margins," London, 1848). This writer tabulated some 2,000 to 3,000 elevations in Great Britain, Norway, Sweden, Belgium, and France, and from consideration of these ordinates, inferred a comparatively recent and approximately uniform submergence of the countries above named to a depth of 1,200 to 1,400 feet.

More recently the above conclusions were confirmed by J. E. Campbell ("Frost and Fire," 1865) and by Prof. Prestwich ("Tradition of the Flood," 1895). The latter author has shown also that the inundation of Northern Europe established above, was confluent and contemporaneous with a similar submergence of great areas in Northern Africa, Western Asia, and Southwestern Europe. That the epoch of this flood was within 8,000 to 10,000 years of the present, and that the depth of the waters increased to the north.

It will be observed that the above-noted investigations have extended over areas so great in extent, that we may describe them as *general*, or continental in their nature. In addition to those studies, however, a great amount of labor has been given to what may be described as *local* examination of beach phenomena, by hosts of observers in Sweden, Norway, Scotland, England, France, and other countries too numerous for enumeration. The so-called Parallel Roads of Glen Roy, to the discussion of which some thousands of pages have been devoted, offer perhaps the most familiar example of these local studies.

AMERICA.

On this side of the Atlantic we may search in vain for evidence of such *general* examination over great areas as seems to have been undertaken in Europe. On the contrary, all our efforts have been local in character. They have been restricted most generally to the narrow limits of a single State, and more often to the still smaller and perhaps fractional area of a single basin.

It is to this peculiarity in our method of attack, the local nature of our system of research, and the necessarily fragmental and imperfect character of all records so obtained, to which we must attribute, in the opinion of this writer, that discord and confusion in ideas as to these shore lines, which now prevail among scientific men.

Notwithstanding, however, the sporadic, spasmodic, and local character of our efforts, much has been already accomplished. The interior basins of our continent have been searched to some extent, although the lowlands of our oceanic borders remain as yet entirely neglected.

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

Some of the more important objects of our study, the so-called "glacial lakes," Warren, Agassiz, Iroquois, Whittlesley, Lundy, Saginaw, St. Lawrence, Passaic, Ohio, Hennepin, etc., a few of the sixteen

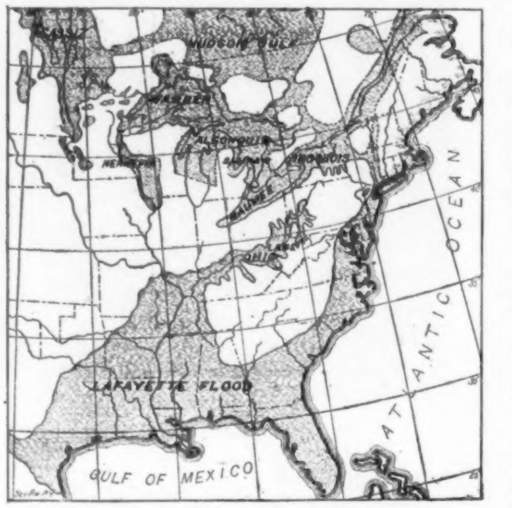


Fig. 1.—Recent Submergences of the North.

Submergences shown as mapped by geologists with Lake Iroquois at the level observed by Chalmers and Fairchild and Lake Ohio united to the Lafayette.

Finger Lakes of Central New York, and a few of the larger ones of the twenty-six glacial lakes in Minnesota, all of which water bodies have been mapped from study of the beaches we are now discussing, are shown in Fig. 1. In addition thereto the Champlain submergence of the Atlantic coast during the Glacial Epoch, as described by Dana, is to a slight extent indicated, as well as the approximate limits of a recent universal flooding of the South, the epoch of which has heretofore been much disputed.

This submergence of the Southern States—the Lafayette Flood of McGee—was originally mapped out from study of the silts, soils, clays, sands, etc., of the flooded region (Twelfth Annual Report, U. S. Geological Survey). It is now demonstrable, however,

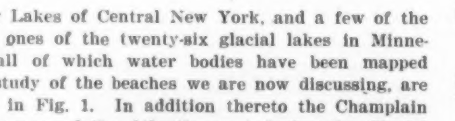


Fig. 2.—Section of High Ground South of Lake Erie.

by means of the raised beaches that this flood was *contemporaneous and confluent*, not only with the Champlain waters of the North, but with Glacial Lake Ohio and the Matanzas inundation of the Antilles. If the Champlain and Ohio waters were of glacial age, as seems well established, *so, therefore, were the Lafayette and Matanzas.* The beaches and terraces of the last-named waters should therefore never be found continuous between these two water bodies; and this writer, in 1886 and 1887, found this to be the case, by following the beaches, deltas, and silts of the Ohio level well into the area of the Lafayette flood.

Mr. Frank Leverett seems also to have confirmed this conclusion. The wide distribution of certain deposits in this region seems to have led him to call in question the alleged Cincinnati ice dam, which had been considered necessary to restrain the Lake Ohio waters. He says: "The silts have been found by the

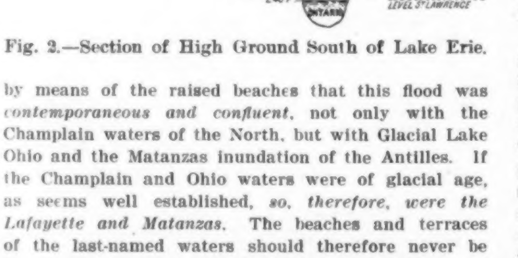


Fig. 3.—Ideal Section Through Raised Beaches.

A. Upper angle of wave-cut shelf. B. Beach ridges. C. Deeply cut terraces. D. Boulevard beach. E. More ancient beaches. F. Faintest of all beach records.

writer to be too widespread to admit of this explanation, since they extend well past Cincinnati, covering much of Southern Indiana, as well as portions of States farther west." (Article "The Cincinnati Ice Dam," Proc. A. A. A. S. 1892.)

These results clearly justify a slight extension of the Lafayette area toward the northeast, to a confluence with Lake Ohio, and the recognition of waters as part and parcel apparently of some systematic submersion of the low-lying lands of the north during the last glacial age.

Elsewhere it will be shown that this conclusion is also made necessary by the still stronger testimony of actual correspondence in beach levels and gradients.

Of the above-named basins, the one formerly occupied by the so-called Lake Agassiz, in Minnesota and Canada, has been studied by Warren Upham in perhaps the most ambitious and valuable work on ancient shore lines that has yet been compiled. (Monograph No. XXV. U. S. Geological Survey. The Glacial Lake Agassiz.)

This work we are now compelled to use as a basis of examination in our study of early methods, for the reason that Upham's work being more exhaustive than that of other writers, we are thus enabled to cover the entire subject. It should be clearly understood, however, that the criticisms to follow are not addressed to Upham alone, but will apply to nearly all writers who have touched upon glacial geology or the raised beaches.

The necessity of making such criticisms as are now contemplated is regrettable, but nevertheless is unavoidable, if we are to advance in knowledge in this matter. Much that has heretofore been accepted must apparently be discarded.

Without further apology, therefore, except to recall the old adage, that "Controversy promotes the truth," we enumerate below the more important items wherein criticism of the principles or processes hitherto applied to these terraces seems most urgently called for.

I.

It has been the almost invariable practice of American observers to assume, at the beginning of an investigation, that the so-called glacial lakes were restrained in their elevated positions by gigantic ice barriers.

The Canadian geologists have repeatedly denied these ice dams, and no evidence has ever been found that such barriers occupied at any time the indicated or mapped position.

In each case these writers have compelled themselves into paths of uncertainty. They have mapped in vivid color a bare inference, a theoretical need, as an undisputed fact. The method cannot be regarded as scientific.

II.

It is assumed in Agassiz that seven distinct beaches, well separated farther to the north, coalesce and merge into one at the north end of Lake Traverse. In other cases it is assumed that three and four beaches merge into one.

It is very true that the higher beaches have the greater inclinations, and by consequence, when plotted, they seem to have a fanlike structure. This peculiarity has been thoroughly established by the writer for many regions other than Agassiz. The terraces thus necessarily approach each other on their progress to the South. But when this plotting to scale has been accomplished, there is perfect demonstration that *they do not converge to an apex at Traverse.* Their meeting place is seen to be at some unknown point far to the south. The axis of "tilting," therefore, if "tilting" in any manner occurred, could have been nowhere in the vicinity of Lake Traverse.

III.

In recording elevations of beaches in the Agassiz basin, the observer almost invariably measured the altitude of crest of the beach ridges bordering the shore line. In the Iroquois region the same practice was generally followed. To the north of Superior Lawson adopted a much preferable plan. He measured with precision the elevation of the *upper edge of the water-carved shelf.* In Ohio and Michigan both systems have been used. On the lower St. Lawrence Lawson's method has most generally prevailed, and it is to be hoped that in the future all observations may be so taken. As illustration of the utility that may follow this uniformity of record, the writer will state that in following these beaches, largely on foot, from the extreme easterly extremity of Nova Scotia 3,000 miles westward to the Dakota plains, he found on his progress four or five points of change where it was impossible to make direct comparison of nearby ordinates. For instance, no comparison, from the published data, can be made between the ridge crest altitudes in Agassiz and the shelf measurements of Lawson in Superior. When allowance is made for the difference in systems, however (supplementing the work with much personal investigation on the grounds), the most extraordinary fact is brought out, that the principal one of the seven Herman Beaches of Lake Agassiz has the precise elevation

tion of the Boulevard Beach in Duluth, *in equal latitudes*, and that these terraces rise to the north on identical inclinations.

The consequent and necessary inference would seem to be that *Lakes Warren and Agassiz were in their time contemporaneous and confluent seas.* The result above reached I merely state; proof will not here be attempted. I can only say that the identity and confluence claimed for these waters is based on at least three years' diligent and laborious effort.

IV.

The determination of the gradient of inclination in the Raised Beaches to this date, by nearly all writers, has been of the most haphazard character.

In Agassiz, the assumed *water level* at Lake Traverse (1,055 feet) is correlated with the *summit of the ridges* farther north, ridges that may be anywhere from 5 to 20 feet above the water's surface. This gives an inclination far above the truth. This error, however, is small compared with that derived from the assumption that seven beaches flow into one common apex at Traverse, and is almost negligible when we pay regard to the fact that Upham almost invariably correlates the *highest* beaches of the low land at the south (1,100 feet near Traverse, 1,500 feet near boundary, 2,200 to 2,700 feet at Riding Mountain) with the *highest* beaches of the much higher ground to the north; jumping in some cases 150 miles from Gladstone to Kettle Hill, without the slightest connecting link to guide the correlation.

In all countries on the globe, with the appearance of greater land elevations, *new beaches* invariably make their appearance, but it is *never safe* to correlate these higher beaches of the high land with the highest beaches of the low land, simply because they are the highest visible in each case, nor can inclinations be determined from the study of five, ten, or fifty observations. On all sides of any observer, at any location, there are always thousands of ordinates. Let inclinations be determined from study of the entire aggregation of data. We may then feel that our work is justified by all that is known. Mr. G. K. Gilbert's inclination of 3½ to 5 feet per mile, rising to the northeast at the eastern end of Iroquois, is perhaps the most unfortunate of all these determinations, as the resulting gradient, announced in 1885, has since become a fixture in geologic literature.

The first suspicion that uncertainty might exist in this long-accepted inclination arose in manner following:

Many years since, this writer, after laboriously mapping in profile all accessible beach elevations along the south shore of Lake Erie, had brought to the southern shore of Lake Ontario at various points between Buffalo and Batavia several well-established gradients, based on many years' labor, and on many hundreds of ordinates, extending continuously westward for some 400 or 500 miles toward Fort Wayne and Toledo. From the high lands south of Rochester these established inclinations were then projected directly across Ontario to the high lands at the northeast. Here these lines, with almost perfect accuracy, seemed to fit and correlate with the 657-foot beach at Adams Center, the 700-foot and high beaches near Watertown, Rutland, and Fine, and with several other terraces located in person in that region. It was consequently assumed, and apparently with much justice, that the slope of the Iroquois shore line was identical with that prevailing for 500 miles to the west.

A great lack of harmony was now apparent between the above-named inclination of a few inches per mile and the earlier determination of 3½ feet per mile. This conflict at once led to a diligent revision of my own diagram, but the result was merely to more strongly confirm my original conclusions, and still greater assurance was later obtained by the prolongation of this same inclination far down the St. Lawrence.

Inquiry was next undertaken as to the methods that had been applied in the earlier determination, and the result was surprising. It seems that Gilbert, from the 363-foot terrace at Hamilton, followed the beach eastward through Lewiston and Rochester to a point near Sodus, N. Y. Here the Iroquois shore line turns southward.

From this 440-foot elevation at Sodus, the observer then passed, for some 50 miles to the northeast, over the lowlying shores and waters of Ontario, *utterly without guide in his flight*, and there made selection of the 563-foot terrace at Richland Junction, and the 657-foot beach at Adams Center, as positive and unquestioned correlatives of the 440-foot Sodus terrace. What induced the selection of these two particular terraces out of the great number at all elevations in the immediate vicinity does not appear. The correlation was therefore unjustifiable.

It is only fair to suppose, however, that at this time Gilbert was ignorant as to the existence of the numerous body of fellow beaches above mentioned.

The proper establishment of the actual inclinations in these ancient shore lines is deemed so important that the descriptive text has been supplemented by Fig. 2, where our method of derivation of slope is clearly exhibited.

The inclination rising to the *south*, announced by Bravais in 1839, for the beaches of the Altenfiord, disputed by Chambers ("Ancient Sea Margins," page 290), and the gradient in Switzerland, by which Heim claimed proof of a recent and considerable sinking of the Alps, are both results subject to the same objections as before; they were based on scanty and imperfect observation. Prof. Penck has already shown the error of Heim as to the Alps. (Proc. A. A. A. S., 1897, page 208.)

V.

In attempting to find a northeasterly inclination to the Agassiz shore lines, in conformity with the alleged direction of slope for the Iroquois basin, the high-level Milnor beaches of the southwestern extremity of the lake were entirely ignored. If these are taken into consideration, however, and reduction is made for the difference between water levels actual and ridge elevations, the inclination obtained and which best fits all the facts of the entire region, is found to be the *true north*, rising in approximate direct ratio to the *sine of the latitude*. This law of direction and rate of slope is furthermore not peculiar to Agassiz alone. *It applies to all terraces in the northern hemisphere* in so far as this writer can discover.

In a recent revision of the data around Iroquois, Prof. Coleman has found that the axis of inclination, instead of having direction toward the northeast, as first determined, must be swung some 28 degrees nearer the north. (Bull. Geological Society Am., Vol. 10, page 169.)

VI.

For the purpose of "obtaining" the northward ascent of the old lake levels in Agassiz, Upham interpolates in the table of elevations on pages 476-477 supposititious water levels at Lake Traverse differing by five feet.

His object in inserting these fictitious values into a collection of genuine observations is not clear, unless they were intended to add support to his theory of tilting. Whatever his purpose, however, the action can not be justified. We should base important conclusions on actual, not imaginary facts.

VII.

As an argument against the practice of recording elevations of the *crest* of coast ridges, so much used, at present, I would urge as follows:

Our ability to determine with reasonable accuracy the height of the water's surface in this investigation should be held of primary importance. If we succeed in this, we can delineate with precision the form and position of the ancient coast line. We can compute the depth of water at any point we choose, and what is still more desirable, we may study with confidence *such relation as there may be found to exist* between the elevations and inclinations of two or more neighboring basins.

What we need then is the nearest possible determination of actual water levels. Now, it is well known that the ridges which fringe to some extent the coast lines of all countries are dependent more on the winds for their position and altitude than on the waves. The waters may excavate the material from some submarine source and spread it upon the beach, but when so placed, this material is at the mercy of the winds, which pile it in high and narrow, or wide and shallow, ridges, at their pleasure. For example, take the sand ridges on the east shore of Lake Michigan. At Grand Haven they have altitudes of over 300 feet. West of Michigan City at the south, they have decreased in elevation until they resemble the ridges of Agassiz. If Lake Michigan should in the future disappear, and some scientist should attempt the reproduction of its present outlines from consideration of the altitudes of these ridges, he would be hopelessly in error. His submergence at the north would be 300 feet in excess of the truth, and his derived inclination would show 2 to 3 feet to the mile beyond the actual condition.

It seems clear, therefore, that the preferable method in our investigation is to always note the *elevation of the upper angle of the water-carved shelf.* This point will always be from 3 to say 10 feet above the actual water's surface, but the resultant uncertainty of say 6 to 8 feet can be *largely eliminated* by giving consideration to the fact that the elevation of this angle is a function of several variables, viz.: With wide water and consequent increase in wave action, the angle will be *high*. With narrow water it will be *low*. With precipitous shore lines, which enable the waves to break directly on the beach, the angle is again *high*. But with shallow water, or offshore bars, causing the waves to break far from the shore line, the angle will again be *low*. Analysis of the topographical situation as above noted has enabled this writer often to reduce apparently irreconcilable ordinates to approximate equality.

Another difficulty in correlation is avoided by refusing to plot ordinates obtained in deep recesses or bays of an ancient coast line, more especially when this bay faces the tidal wave moving northward in the Atlantic. Illustration of this idea is shown in the 50-foot tides of the Bay of Fundy, the upper reaches of which would apparently bear no relation to the general shore line of the present Atlantic. With sufficiency of observation, however, extending entirely around the bay or recess, these inharmonious ordinates would be *self-correcting*. They would show a curve rising slowly to some 40 feet above the general elevation and gradually declining to the original level. Safety, therefore, lies in numerous observations.

VIII.

Many observers have inferred identity of two or more beaches, which may be not too remotely separated, through similarity in appearance, equality in development, similarity in beach contents, or perhaps through their happening to have elevations which fit some preconceived idea of tilting or gradient.

No dependence can be placed on such inferences. It is generally accepted that the date of most of the terraces of the so-called Glacial Lakes is within 8,000 to 10,000 years of the present, and it is believed that the waters receded from their elevated position with some considerable rapidity. It is, therefore, highly probable that there may be but one or two thousand years, more or less, difference in age between the highest and the lowest of the recent series. It is consequently to be expected that both in *appearance* and in *contents* there may be great similarity between even the highest and the lowest member of any one system.

IX.

Much difficulty arises in correlation of barometrical altitudes, especially if unreduced. It would tend enormously to the value of these observations if exact elevations could be determined by level. Many observers give elevations in a casual manner. The utmost attainable accuracy should in each case be attempted, and the records should always give altitudes above mean sea level, and not above some river, lake, or railroad.

X.

Too little attention has been given in the past to recording the *apparent difference* in age between beaches of different elevations in the same location. R. R. Hice has noted "the apparent age of the higher gravels" in the Lake Ohio Terraces, but he failed to give the elevation at which the *change in appearance* begins. Darwin noted that in the low terraces of South America the fossil shells were fresh and sound, in the high terraces they were brittle and decomposed. Roeminger notes much difference in apparent age in the northern part of Lower Michigan. Lawson in speaking of ancient shore lines on the Pacific Coast says: "The higher terraces being much older have suffered more from degrading forces, and so appeal less strongly to the eye." (Bulletin No. 8, Vol. 1, University of California, page 248.) N. H. Winchell has also noted this difference at various points in Minnesota, but in not one of these cases did the observer note the altitude at which the change in appearance occurred. The writer has found, however, that in the Lake Superior region this difference commences precisely at the Boulevard Beach, or say at about 1,073 feet near Duluth; the Boulevard and all lower beaches being sharp in outline. In Lake Agassiz, in the *same latitude as Duluth, the change begins* also at the Herman Beach, or at 1,073 feet, as in the Superior Basin. South of Mackinaw the change occurs at about 1,000 feet. In the basin of Lake Ohio it takes place at from 930 to 960 feet, the higher elevation to the north. In all these cases, except in Agassiz where it is less distinct, the abruptness in alternation from the sharp angular outlines and lesser degradation of the lower terraces, to the rounded angles and heavy erosion of the higher benches is pronounced and unmistakable.

The interesting feature in this discussion is found in the fact that this change, in every case the writer has examined, begins *precisely at the upper level of the so-called Glacial Lakes.* If this law holds good in other cases, it will be of immense value in mapping out and distinguishing terrace elevations of the last Northern Submergence (which we should first delineate) from those of some previous submergence or submergences, which from the evidence now before us seem to have been of much greater age. From long study of these older terraces, it would seem necessary to conclude that we have here a system of beaches entirely separate and distinct from those of the last glacial epoch. And this writer believes it quite probable that these older shore lines, from their appearance alone, will eventually be again subdivided into what may be styled old, older, and oldest systems.

It is the writer's experience with these older and younger beaches, that if study and consideration be given to the apparent relative amount of degradation and erosion between the most recent of the terraces and that system apparently next older, it will be invariably decided that the time interval between such series must be *greatly in excess* of the lapsed

interval since the carving of the most recent terrace. This leads to the inference that the youngest of the older terraces antedate enormously those of the so-called glacial age.

All these questions are of much interest, and it is, therefore, desirable that the relative ages in shore lines should always be noted, with *careful attention to the elevation where the change occurs.*

XI.

Very often it is possible from the study of spit, or bedding, or other phenomena, to predicate the direction of flow in the current which washed these shore lines. This information may assist in fixing the direction from which geologic deposits may have been transported. It is, therefore, desirable to make these observations when practicable.

XII.

Over a half century ago Robert Chambers called attention to the fact that certain beaches in England and Scotland are more deeply scored and more prominent than others. ("Ancient Sea Margins," page 276 and onward.) Of the fifty or more shore lines below the 1,400-foot level in Great Britain, he enumerates in various places some eight to ten as being particularly persistent and well developed wherever encountered. To this statement I would now add that the same law holds good in America and has been of the utmost value to the writer in correlation of elevation.

It seems that in the eastern United States, both to the north and the south, when one of these strongly carved terraces appears, the next adjoining terraces, both above and below its level, through vertical distances of 100 feet or more, are *almost invariably faint and obscure.* This particular terrace is, therefore, easy to distinguish in nearby locations, and further-more, in extending our research over a wider territory, it is almost certain that the number of observations of this deeply impressed beach will be five or tenfold in excess of those of its more obscure neighbors.

At a later period, when we have plotted these ordinates to scale, the great preponderance of points, following in close array one particular law of slope or inclination, simplifies enormously the labor of classification. Attention is called to this law in hopes that others may likewise find assistance through its means.

(To be continued.)

SUNS AND NEBULÆ.—I.*

AN ALTERNATION OF GENERATIONS.

BY SVANTE ARRHENIUS.

ALTHOUGH the sun is so hot and so huge that it can maintain its lavish expenditure of heat for trillions of years it must ultimately grow cool and become covered with a solid crust. At first this crust will often be punctured by eruptions of hot gas and lava but with the thickening of the crust the wounds will heal and only a few scars will be marked by volcanoes, which will give egress to water vapor, carbon dioxide and other gases liberated by the cooling of the interior. Then the water vapor will condense into oceans and for a time the sun will resemble the earth in its pres-

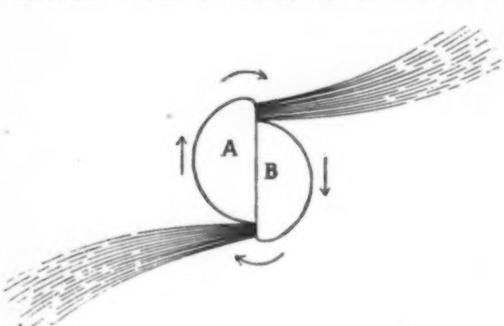


FIG. 1.—COLLISION OF TWO SUNS.

The straight arrows indicate the direction of motion before collision, the curved arrows the direction of rotation of the combined mass after collision. Streams of matter derived from explosive compounds released from pressure by the collision rush forth from the extremities of the diameter which is parallel to the original direction of motion.

ent condition, except that, as it will receive no appreciable heat and light from without, it will be destitute of life and will cool rapidly. Soon the seas will freeze and the cooling will be accelerated by the precipitation of the clouds. Then the carbon dioxide of the atmosphere will fall as snow. At —330 deg. F. new seas, composed chiefly of liquefied nitrogen, will begin to form, and at —365 deg. F. the residual atmosphere will consist of hydrogen, helium, and a little nitrogen.

The sun's interior will then, as now, have a temperature of millions of degrees and will contain vast quantities of explosive compounds, and the gradually thickening crust will preserve its heat and energy almost undiminished through trillions of years, as the

* Illustrated with photographs taken at Yerkes Observatory.

FIG. 4.—THE GREAT NEBULA IN ANDROMEDA.

FIG. 2.—THE SPIRAL NEBULA IN URSA MAJOR.

FIG. 3.—THE SPIRAL NEBULA IN CANES VENATICI.

SUNS AND NEBULÆ

small loss by radiation will be almost balanced by the heat supplied by the fall of meteors.

In time—perhaps in a quadrillion of years—the sun will collide with another sun, which will probably be dark like itself, for there are probably a hundred extinguished suns for every luminous one.

Occasionally a new star blazes forth in the sky and

FIG. 5.—CENTRAL PART OF THE GREAT NEBULA IN ORION.

rapidly diminishes in brilliancy until it becomes nearly or quite invisible. The most remarkable example is the star that appeared in Perseus in 1901. When discovered on February 22 the star was brighter than the 3d magnitude, yet a photograph made 28 hours before and showing stars of the 12th magnitude, contains no trace of it. On February 23 it was brighter than any star except Sirius, and on February 25 it was still of the 1st magnitude, but it had fallen to the 2d on February 27, the 3d on March 6, and the 4th on March 18. Thereafter its brightness fluctuated, with a period at first of 3 and later of 5 days, and its average brightness declined. Since June 23, 1901, it has declined more steadily and is now of the 12th magnitude. Its color, at first blue-white, soon became yellow and then red. During its period of fluctuation it was yellowish white when brightest and ruddy when faintest but it has since become pure white.

In the spectra of new stars the bright lines of hydrogen and some other elements are bordered by dark lines on the side toward the violet. This indicates, probably, that comparatively cool masses of gas are rushing toward us with enormous velocities, while the luminous and hotter parts are stationary or receding from us. The displacement of the hydrogen lines of the new star in Perseus corresponds to a velocity of nearly 450 miles per second. Of course the gas is expelled in all directions but we can detect only the streams that flow toward us.

The continuous spectrum and the lines of the metals gradually faded, but the hydrogen lines remained. So did certain lines which are characteristic of nebulæ and are ascribed to a hypothetical element "nebulium." Finally the spectrum, like those of other new stars, became quite similar to the spectra of the nebulæ.

From April, 1901, to March, 1902, the new star was surrounded by two cloud rings, which receded from it with velocities of 1.4 and 2.8 seconds of arc per day. It is computed that they must have started from the star about the time of its greatest brilliancy. Doubtless they were expelled by radiation pressure.

In the sudden appearance of this star we evidently witnessed the magnificent termination, by collision, of the independent existence of two heavenly bodies. Before the collision both bodies were either dark or of smaller aggregate luminosity than a star of the 12th magnitude. After collision, as they were brighter than a star of the 1st magnitude, although distant from us at least 120 light-years, or 700 trillion miles, their radiation must have been thousands of times greater than that of the sun. Hence the radiation pressure must have been much greater than the sun's and the velocity of the dust correspondingly greater than that of solar dust, though less than the velocity of light, which cannot be produced by radiation pressure.

It is not difficult to estimate the force of the impact of these dead suns. A meteor falling from infinite distance to our sun would attain a velocity of about 375 miles per second, and the velocities of these colliding suns must have been of the same order of magnitude. Usually, the impact would be eccentric and

transformed into heat, enough would remain to give the surface of the combined mass a rotational velocity of hundreds of miles per second. As the equatorial rotational velocity of our sun is only 1.25 miles per second, it is probable that the original rotary motions of the colliding bodies would have little effect on the result. The first effect of the collision is the expulsion

FIG. 6.—NEBULÆ IN THE PLEIADES.

of two streams of matter in opposite directions in the plane of rotation, resembling the fiery trains of a "pin-wheel" except that they are directed forward instead of backward (Fig. 1). The sudden decomposition of the explosive compounds thus brought to the surface and released from pressure would cause great volumes of gas to be expelled with violence. Both the linear and angular rotational velocities of the

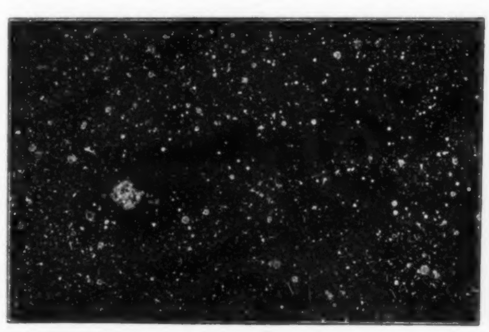


FIG. 7.—A STAR AND ITS WAKE IN CYGNUS IN THE MILKY WAY.

streams would diminish as they recede from the center. The gases, which are quickly cooled by expansion, contain fine dust, chiefly carbon derived from the explosive compounds, and the gradual accumulation of this dust veils the new star and causes it to appear yellow and then red. At first the dust clouds of Nova Persei lay close to the star and revolved so swiftly that they appeared to surround it, but by March 22, 1901, the outer parts of the streams were far from the center and had a period of revolution of six days. Hence, as there were two streams, the star was darkened every third day. As the clouds continued to rise their period of revolution increased to ten days, and the period of fluctuation to five days. Meanwhile the selective absorption of light by the clouds grew less marked, owing to the aggregation of the dust into coarser particles—the finest dust, perhaps, having been driven away by radiation pressure—and so the star gradually became white again. Its persistent whiteness indicates that its temperature is still very high although its apparent brilliancy is diminished by a uniform envelope of dust laden gases.

We see that this theory correctly represents the observed phenomena, even in detail. The spectroscope shows that this, like other new stars, has become a stellar nebula. The continuous spectrum has been weakened by the dust clouds surrounding the glowing center and the impact of the dust particles, impelled by radiation pressure, against the molecules of hydrogen, helium, and "nebulium" which chiefly make up the outermost layers, together with the discharge of the negative electricity of the particles, excites these gases to luminescence and produces a light identical with that of nebulæ.

Furthermore, centrifugal force has given the nucleus nearly the form of a disk. The center still possesses the high temperature and pressure and comparatively high density of our sun, while the outer parts are as cold and tenuous as a nebula. Ritter has calculated that the heat produced by the collision of two equal suns would suffice only to expand the mass to four times its original volume. Hence the greater part of the mass probably remains near the center. Around the central body revolve the remnants of the spiral streams which were ejected immediately after the collision. Much of their matter is probably flying off into space and will ultimately become attached to other heavenly bodies or join the great irregular nebulæ that envelop the star clusters. Another portion, unable to escape the attraction of the nucleus, continues to revolve around it very slowly. The result will be the partial obliteration of the spirals and their transformation into rings.

This spiral structure (Figs. 2 and 3) has long been observed in the outer parts of nebulæ, and in nearly every case the spirals are two in number. The great nebula in Andromeda and some others appear spindle-shaped (Fig. 4) but close examination with powerful instruments proves that they are flat spirals, the edges of which are directed toward the earth. The American astronomer Keeler, who devoted himself to the study of nebulæ, found that nearly all of them show spiral structure.

A few, known as planetary nebulæ, appear to be spherical, probably because the explosions were less violent and the spirals lie near together, or because all inequalities have been effaced by time. The nebulæ in a few others are ring-shaped. In these cases the spirals may have become obliterated and the inner parts condensed upon planets revolving around the central sun. Schaeberle has detected traces of spiral structure in these nebulæ.

Very different in form are the immensely extended and exceedingly tenuous irregular nebulæ, like those of Orion, the Pleiades, and Cygnus (Figs. 5, 6, and 7), but spiral structure has been detected in parts of these, also.

A central or nearly central collision would produce a disk-shaped or conical nebula, through the uniform extension of gases in all directions.

The size of the nebula depends on the ratio between the velocity of expulsion and the mass of the system.

FIG. 8.—STAR CLUSTER IN MESSIER 15 PEGASI.

FIG. 9.—STAR CLUSTER IN MESSIER 13 HERCULES.

SUNS AND NEBULÆ.

The gases expelled with more than a certain critical velocity—560 miles per second in the case of the collision of two suns like ours—escape into space, while the slower portions remain about the central mass, with which they are prevented from re-uniting by radiation pressure and centrifugal force. The pressure exerted by the radiation of the glowing nucleus balances the gravity of dust particles and holds them in suspension, and the gas is supported by the friction between it and the dust. The intensity and, consequently, the pressure of the radiation are diminished by its passage through the dust and hence there is a limit beyond which not even the finest particles can be held in suspension and which is the limit to the extension of the nebula. Again, the rapid rotation which follows all except the exceedingly rare central collisions tends to counteract the central attraction and also to flatten the nucleus into a disk. Molecular collisions and tidal forces tend to produce a uniform angular velocity and efface spiral structure in the inner and denser parts but in the outermost parts of the nebula these forces, as well as gravity, are so feeble that any mass preserves its original form almost to infinity. The central body is a sun, at first of extreme brilliancy, but rapidly losing brightness in consequence of intense radiation.

Though the outer parts of these nebulæ are exceedingly rarefied they are able to arrest dust showers from distant suns. For the retention of these parts by an infinitesimal central attraction implies that they have very small molecular velocities, that is, temperatures little above the absolute zero. At such temperatures a great role is played by the phenomenon which Dewar calls absorption. The dust particles form centers of condensation for the gas and when they collide they are cemented together by their envelopes of condensed gas, which acts like a liquid. Thus, numerous meteors are formed, especially in the inner parts of the nebula.

Through this medley of meteors and gases sweep stars and their dark satellites, which carry off the nebulous matter and leave empty channels behind them, as is strikingly illustrated by Wolf's photograph of the nebula in Cygnus (Fig. 7). Many such "rifts" are seen in the great irregular nebulæ. Smaller and slower intruders, on the contrary, are arrested but they also collect about them the particles and gases of the nebula. Hence nebulæ often contain multitudes of small stars and are surrounded by almost starless spaces. (Figs. 8 and 9). Thus the nebula is gradually transformed into a star cluster.

Herschel's theory of nebulæ differs from this only in assuming that the nebulous matter condenses directly into stars without the aid of immigrant bodies.

Kapteyn estimates the average distance of 168 nebulæ as equal to that of stars of the 10th magnitude, or 700 light years. Hence the old assumption that nebulæ are incomparably more remote than the faintest stars is erroneous.

(To be continued.)

THE MOSQUITO AS A SANITARY PROBLEM.

DISEASES CAUSED BY MOSQUITOES.

BY EDWARD A. AYERS, M.D.

MALARIA.

What a curiously reversed sequence has been the history of malaria! False in its baptismal name—"bad air"; used as a dumping ground for every stunted diagnosis for symptoms that bore any resemblance to its characteristics; in its unfolding it suggests a vitascopic picture series reversed in action. An unknown entity and falsely named, its *cure* was discovered two hundred and forty years before it was known what was cured; and from that time until 1878 no progress—the biograph stood still.

Then its pathology begins to appear upon the screen, and by the end of the nineteenth century its cause is known; and now we know how to prevent it.

Following Laveran's description of the erethrocytic development of the parasite, A. F. A. King in 1883 published a strong *a priori* argument pointing to the mosquito as man's inoculator, and against air and moisture sources. His views were corroborated by the findings of Koch, Laveran and Pfeiffer in 1884. The functions of the gametocytes, or sexual forms of the parasite, were next argued over by Bigmani, Laveran, and Manson; W. G. MacCullom demonstrating their male and female character and product—the zygote, or fertilized ovum. In 1894 Manson informed Major Donald Ross of his belief that this zygote rounded out its development in the mosquito; and Ross proved this view correct in his three years' investigations in India; and that the sporozoite, or seed, was ejected from the salivary gland of the Anopheles into man's blood.

THE LIFE CYCLE OF THE MALARIAL PARASITE.

Most interesting is the life cycle of the malarial parasite when freed somewhat from its confusing and unfamiliar terminology.

Protozoa reproduce both by simple cell division—the asexual method; and by formation of male and female cells—the sexual method. The malarial protozoon pursues both these methods in its man-mosquito cycle; the asexual in man and the sexual in the mosquito.

Let us break into this continuous chain circle at the point of infection of man by a mosquito. When the latter makes her usual contribution of acrid saliva on sucking a man's blood, it will contain—assuming an infected mosquito—a number of sporozoites, or malarial protozoic seeds, which are minute amœboid bits of protoplasm, having considerable motility. They penetrate the red blood corpuscles, in which they develop by division into a number of cells which fill the red blood corpuscles, and then burst free into the blood plasma—liquid. These cells are called merozoites, or germ cells. These sexually incapable merozoites do as did the sporozoites, enter other blood corpuscles, and repeat the performance, accompanied each time with the familiar chill and fever. This process of cell formation is called schizogony, which means splitting open. After this asexual schizogonous cycle has been repeated a number of times—produced several generations of sexually immature merozoites—some of them acquire capacity to sexually develop, a portion as male and a portion as female in function. These sex-differentiating cells are called gametocytes—from *gamete*, a spouse, and *cyte*, a cell—an immature gamete. The masculine type will be called a microgamete, the feminine macrogamete when matured.

One of the fundamental peculiarities in parasitic life, as in that of bacteria, is the limitation in what each can eat. Many protozoa can only grow in blood corpuscles; others in organs and blood vessels; and others in intervascular tissues. The malarial protozoa are omnivorous, yet only in stages of growth; so, strangely, the micro and macro gametes, with all the superb food elements possessed by human blood, cannot advance sex mating and seed generation therein, but must find it in the stomach, stomach wall, and tissues of the mosquito; and more wonderful still, only in the individualized juices of certain subdivisions of mosquito genera. Such are the ultra-refinements of enzymes, of ferments, the tools of all carpentry in life construction. Manson states ("Tropical Diseases," fourth edition, 1907) that the parasite has been observed in some thirty-four Culicidæ in addition to the *Anopheles maculipennis* Meigan.

When the merozoites escape from the red blood corpuscles into the blood liquid, causing chill and malarial fever, the man is "primed" for spreading the disease to any biting female *Anopheles maculipennis*. Such females, sucking a stomachful of this blood, will draw in male and female merozoites, now called gametocytes—micro and macro gametocytes. These bodies have acquired a half-moon shape, and are hence expediently called crescentic bodies, or crescents. The gastric juices of the mosquito do not digest these gametocytes. Becoming mature and round, the macrogamete—the analogue of the ovum in human embryology—extrudes a portion of its nucleus, and is fit for fertilization. The microgametocyte divides its nucleus and forms radiating threads, called flagellæ, the analogues of spermatozoa, which separate from the mature microgametocyte, now become a microgamete, and thrash about with great activity. One of them penetrates the mature macrogamete, fertilizes it, and the product is called a sporont—an immature seed-forming cell. This formation of sporonts is called sporogony.

The sporont, or fertilized ovum, must acquire a burrowing capacity to enable it to traverse the wall of the mosquito's stomach. So it elongates and acquires locomotile power. It is now called an ookinet, a moving egg, also a vermicule, a little worm. It worms in between the epithelia of the stomach wall, where it finds just the food it needs; and waxes round or ovoid in its quiet abundance. It is now a zygote, or zygospore—a fertilized ovum. Ere we have memorized its triplicate names ookinet, vermicule, and zygote, it becomes an oocyst, or capsule holding egg germs; and then proceeds to subdivide into numerous sporoblasts, or seed germs; each one of which will still further divide into many sporozoites, or protozoic seeds.

These minute sporozoites, with amœboid activity and motility, travel extensively throughout the length and breadth of anophelic anatomy; and many, drawn by what Ward calls "the chemotatic influence in the salivary glands," enter the ducts of these organs, from whence they pass with the saliva through the mosquito's proboscis into the blood of man; thus bringing us to the point in the malarial parasitic cycle at which we began, but not in the same man.

It is related of Lincoln that he did not understand the meaning of the word *demonstration* until he studied Euclid.

While such mathematical demonstration is the highest form of proof, yet the evidence obtained and employed to demonstrate the guilt of the *Anopheles maculipennis* in causing malaria in man is sufficient to meet the requirements of any rational student. Ross gave microscopical eye proof of the successive stages of malarial parasitism from birds to mosquitoes, and *vice versa*. Grassi followed in 1898 with proof that certain Anophelæ were always present in regions of malarial development. Bigmani imported Culex and Anophela genera into Rome, and manufactured a case of aestivo-autumnal or malignant tertian fever by bunking them with a healthy man, and worked to further exactitude by further tests, which pointed to the *Anopheles claviger* as the infector. Then mosquitoes of supposed non-infection were fed on blood from malarial-fevered men, and the sporogenous cycles ensuing were carefully studied. Bigmani then expressed tertian infected Anophelæ to Patrick Manson, Jr., in England; the latter giving them food of his own blood, for which hospitality he was paid in current anophelic sporozoites, and developed a mild tertian fever. Later Golgi showed that there were form differences between the quartan and tertian parasites.

Since then only confirmation of the guilt of the *Anopheles maculipennis* Meigan has followed from investigations in various parts of the world.

YELLOW FEVER.

The history of yellow fever is the prize offering of medicine in competition with dramatic fiction. So essentially theatric is it in its furiously concentrated attack, so like a cyclone cutting its swath of death through a peace-dwelling community, it has been held in far greater awe than its co-worker malaria, although the latter has slain its hundreds for every human being destroyed by yellow fever.

Malaria, like the poor, we have always with us, and it is more easily cured than yellow fever. The wonderful discovery by Jenner of the vaccine that manacled the great decimator smallpox was the most momentous to all civilized peoples in the history of disease; but the swift and successful running to earth of yellow fever by the United States commission on Cuban soil in 1900 had just the touch of heroism to round out a tragic drama, and concentrate the honors upon the famous four: Reed, Carroll, Lazear, and Agramonte. Let us not begrudge their conversion into popular heroes; but lest we forget, let us retain our scientific equipoise, and award a proper measure of the glory that is enough for all to Klencke, Laveran, Manson, Ross, and many others, and particularly Finlay—essential links in the chain of discovery.

Nott, of Mobile, in 1848, academically charges the cause of yellow fever to mosquitoes. Beginning in 1880, Dr. Carlos J. Finlay, by processes of admirable inductive reasoning and repeated experimental inoculations of non-immunes, in the course of eighteen years reached these conclusions:

1. That the germ of yellow fever is only pathogenous for human beings when introduced by inoculation.

2. That the regular process by which it is accomplished in nature is through the bites of the Culex mosquito (*Stegomyia fasciata* Theob.), the insect having previously become contaminated through the act of biting a yellow-fever patient within five days of his attack.

3. That although the bites of a recently contaminated mosquito can produce at most only a very mild attack of yellow fever, or simply confer latent immunity without eliciting any obvious pathogenic mani-

* Abstracted from the Wesley M. Carpenter Lecture, read before the Academy of Medicine. The Editor of the Scientific American Supplement has omitted those portions of the lecture dealing with the life [illegible] the mosquito as a carrier of disease and the ex- [illegible] the reason that the subjects in question [illegible] these columns.

festations, the bites of the same insect, when its contamination dated back for several days or weeks, might produce severe or fatal attacks.

4. That the yellow-fever mosquitoes, after they have once become contaminated, retain the power of inoculating the disease the rest of their lives.

5. That yellow fever might be stamped out of Havana by just such methods as were adopted by Col. W. C. Gorgas with signal success in 1901.

It must be recognized from these remarkably near-truth conclusions of Finlay, that the lines of final experiment were well mapped out for the Commission of 1900. Nevertheless, the subsequent work of this commission constitutes a most brilliant and heroic marshaling of evidence by exclusion and inclusion; by mosquito culturing and self-sacrificing inoculation; by microscopic tests and avoidance of all possible errors; the whole making a presentment worthy to rank with a Euclid demonstration.

The deplorable death of Jesse Lazear from accidental inoculation in the beginning of the work; the premature death of Walter Reed from gangrenous appendicitis originating in profound bodily exhaustion; the physical and other trials of James Carroll through nearly seven years delay in receiving adequate salary and rank, only to die within the year, are familiar pictures of the final death grapple with yellow fever. Yet we have in our profession many men who would look upon their risk with their possible achievements as an exalted privilege.

What did the Reed commission prove?

1. That yellow fever can only be acquired by man from the injection into his blood, when bitten by a mosquito, of a germ or parasite as yet unknown; or by direct injection of blood taken from a man infected with yellow fever.

2. That the variety of mosquito involved is the Stegomyia, which must herself have become infected by biting a yellow-fevered human being within the first few days of his attack.

3. That this mosquito only so infects (bites) man when the temperature is about 80 deg. to 82 deg. F.

4. That no clothing or emanations from yellow-fever patients (fomites) can excite the disease in others.

5. That there is purely a toxic form of infection, self-limiting, and chemical in character.

6. That bites by mosquitoes with recently acquired yellow fever may cause a mild form of yellow fever, which after repetitions gives an acquired immunity.

Thus are two great acts in this Yellow Jack melodrama completed: Unfolding of the plot—the theories of Finlay; proof of guilt—the demonstrations by Reed and fellows. But there is no anti-climatic lag in interest through the short, sharp enactment of the third act—the practical test, with Col. W. C. Gorgas in command.

In the forty-seven years preceding 1900, 35,952 residents of Havana died from yellow fever, a constant mortality of one in every ten of her inhabitants. Under the vigorous control of Col. Gorgas, yellow fever was completely exterminated in ninety days—a fitting climax this, the most brilliant sanitary performance the world has ever beheld.

Havana's yellow fever chart from 1881 to 1901, during which its cause and prevention were fairly recognized by Finlay, shows an average annual mortality of 449; a striking evidence of the difference between the powers of academic and applied knowledge; but the most important teaching the Finlay-Gorgas era offers is that in such essentially wholesale sanitation, government organization and aid are absolutely necessary to success. In achieving its notable victory through its agents, our government has incurred a demonstrated obligation to complete what must constitute the fourth act of our sanitary drama—prevention of all homomosquitic diseases by extermination of the insect.

The variety of mosquito which transmits yellow fever, heretofore known as the *Stegomyia fasciatus*, has been officially classified as the *Stegomyia calopus* Meigan.

THE EXTENT OF HOMOMOSQUITIC DISEASES.

FILARIASIS.—According to Jackson, the filarial worms are in the blood of from ten to fifty per cent of the peoples of the tropical and subtropical portions of the globe; representing the blood vigor of many millions of human beings sapped for a useless worm that offers no other service in God's universe than obstruction to human progress.

MALARIA.—Wherever mosquitoes exist, the malarial Anophelæ are liable to be found. If we take continental United States as a base for estimating malaria's world prevalence, we find in the census that 18,594 deaths were charged against it in the year from May 31, 1889. During the next ten years the death rate fell from 19.2 per 100,000 to 8.8 in the registration area—which is about one-third the whole. Much of this reduction was due to more accurate exclusion of non-malarial diseases; but the steady decline in successive years to 6.3, 5.4, 4.3, and 4.2 by 1904 is largely due to knowledge of mosquito relations thereto. In Italy the mortality during the last few years has fallen from over 15,000 to 4,700 (annually?) (Journal A. M. A., September 7, 1907, p. 862). The government exploited quinine at cost or less, and the purchase of 45,000 pounds in 1906, in addition to systematic protection against mosquitoes, divides the credit of saving over 10,000 lives. But quinine, like kerosene spraying instead of draining, is now an anachronism; and, placing the mortality at three per cent, for every dollar expended for quinine, applied to the spade, it will save more lives, and ultimately prevent the annual occurrence of malaria in a half-million Italian inhabitants.

YELLOW FEVER.—During the past hundred years 100,000 of our people died from yellow fever, and some 500,000 were infected. ("Howard A. Kelly, Walter Reed, and Yellow Fever.") It is a safe prediction that in the years to come, it will appear sporadically and destroy a few lives, as it recently has in Cuba, until governments make life not worth the while to the *Stegomyia calopus* Meigan.

WINTER DISEASES OF HOUSE PLANTS.

HOW THEY MAY BE PREVENTED.

WITH proper care it is possible to employ the same plants for the adornment of the garden and veranda in summer and the house in winter, but species that flower profusely in summer require rest in winter, and, consequently, are not desirable house plants. All plants, indeed, have alternating annual periods of activity and rest. This alternation is most conspicuous in bulbous and tuberous plants and it is also sufficiently obvious in woody plants which shed their leaves in winter. To this class belong most of our common trees and shrubs and also numerous ornamental species—fuchsias, hortensias, roses, pomegranates, etc.—which in winter are destitute of all beauty and, if they require protection, are usually stored in the cellar.

But many evergreen foliage plants are also quite inactive or dormant in winter. Among these are palms, India-rubber plants, azaleas, camellias, and the very pretty coffee plant, all of which are very desirable as house plants because they retain the beauty of their foliage through the winter and require comparatively little light and care. Yet unfavorable conditions will cause the tips of palm fronds to wither and dry up, and the leaves of India-rubber plants, azaleas, and other species to lose their pert stiffness, and droop, turn yellow, and finally drop off.

Foliage plants are usually kept far too warm. Even tropical plants are more apt to suffer from too much heat than from too little. Plants should never be placed near stoves or artificial lights, the direct radiations from which are always injurious if long continued. The amateur naturally thinks of the florist's greenhouse and endeavors to approximate to its temperature, as he conceives it, but the greenhouse is by no means so hot as it seems to a casual visitor. It is the humidity of the greenhouse that makes it appear so hot, and humidity is precisely what is lacking in the dwelling, especially if it is heated by steam or hot air. Furthermore, experience has proved that tropical plants can endure a higher temperature if the air is moist than if it is dry. The humidity of the air of greenhouses is usually 80 or 90 per cent, and for some plants it is raised to 100 per cent; that is, the air is saturated with moisture.

The normal humidity of a house in winter is 60 or 70 per cent, but in steam-heated rooms in very cold weather the humidity often falls 30 per cent below the normal value. This abnormal dryness may be remedied, to some degree, by placing saucers of water on the radiators or registers or by sprinkling the floor. The pollution of the air and other injurious effects of artificial illumination at night is frequently added the lack of sufficient light by day, if the windows are too small or are darkened by curtains, or the plants are too far from them. In very dark rooms only two evergreen foliage plants thrive fairly well, the plectogyne and the philodendron.

Errors in the location and treatment of house plants are revealed by certain symptoms. The drying and hardening of the tips of leaves indicate insufficient moisture in the air, the drooping and yellowing of the foliage of plants with large leaves show that the temperature is too high. Another infallible symptom of excessive heat and dryness is the appearance of various small insects. Of these the aphis or plant louse is most easily detected but the under side of the leaf is often infected with more injurious parasites, which are almost invisible to the naked eye. Washing the leaves with soap or tobacco infusion gives only temporary relief. The trouble soon returns unless the unfavorable conditions are removed. Another symptom of ill health is the precocious growth of plants that naturally remain dormant all winter. The inexperienced amateur is pleased to see the white shoots put forth in December or January by plants that should then be resting, but the pleasure is short-lived, for the untimely growth is made at the cost of the reserved store of energy, the young shoots remain white in default of air and sunlight, and the plant soon dies of exhaustion. Sudden loss of foliage by evergreen plants indicates either acidity of the soil caused by excessive watering or an unhealthy condition due to chilling. Great and abrupt changes of temperature, drafts from windows opened in freezing weather or the application of ice-cold water to the roots may produce such effects. Evergreen plants, even if they are almost dormant, require some water to replace the loss by evaporation from their leaves in the hot dry air, but they need much less in winter than in spring and summer, the season of rapid growth. Many cactuses and other plants, which are protected against excessive evaporation by nature, are best kept quite dry in winter, but there are winter blooming and some other species of cactus to which this rule does not apply.

Winter blooming house plants may be divided into two classes: forced plants and plants which naturally bloom in winter. Most of the former class are plants which naturally rest in winter and bloom in spring but are induced by the heat of the house, sometimes following a period of greenhouse culture, to forego part of their winter sleep and bloom far in advance of their natural season. In this class are the tulip, hyacinth, lily of the valley, lilac, etc. All of these plants are injured by exposure to the sun in winter and they need comparatively little light of any sort. Heat and moisture are the two things essential to early and profuse flowering. The second class comprises plants which bloom in our winter because they are natives of climes with seasons that do not coincide with ours. Among them are the camellia, the ananas, the Alpine violet, and many exotic orchids, balsams, and primroses. These natural winter bloomers are children of light, and they thrive best near a south window which admits a flood of sunshine.

The smaller sorts may be planted in a long and narrow window box, in a single row, so that each plant may receive the greatest possible amount of sunlight. In very cold weather, however, it is prudent to move the box a little away from the window.

Flowering plants of both of these classes, unlike foliage plants, require frequent and copious watering. The water should always be slightly warm and care should be taken to avoid wetting the leaves and stems, especially those of herbaceous plants. Herbaceous flowering plants exhibit a strong tendency to rot in winter and sprinkling produces spots on the leaves. Decayed parts should be cut away and the cut surface, if large, dusted with wood charcoal. (An occasional sprinkling is beneficial to most foliage plants.) It should also be remembered that few winter bloomers can endure the temperature of highly heated dwelling rooms. Most of them, including orchids and pineapples, do much better and bloom longer in rooms kept at a temperature of 50 or 60 deg. F. In such conditions some orchids remain two months in full bloom, and Alpine violets bloom until spring, instead of drooping and dying in a few days, as they often do in an overheated and excessively dry atmosphere.

All house plants should be packed very carefully in non-conducting material for transportation in cold weather, especially if they are taken from a hot room or forcing house without being hardened by remaining awhile in cooler air. Recent experiments have proved that tender plants may be killed by a few seconds' exposure to the open air in cold winter weather.—Reclams Universum.

The Chicago Examiner is said to have made a contract for 25,000 six-pound flatirons to be used as premiums with subscriptions to that paper. The contract provides for the immediate delivery of 5,000 irons.

ENGINEERING NOTES.

For a long time the natural fuel of internal-combustion engines was city gas, but this was too expensive except for engines of small capacity. It was seldom found economical to operate units of more than 75 horse-power with this fuel. Cheap gas was essential for the development of the gas engine, but the early attempts to produce cheap gas were somewhat discouraging, and for a time the probability that the gas engine would encroach to any extent on the field occupied by the steam engine seemed very remote. The theoretical possibilities of the internal-combustion engine operating on cheap fuel promised so much, however, that the practical difficulties were rapidly overcome, with the result that the internal-combustion engine is rapidly becoming a serious rival of the steam engine in many of its applications.

The coal mines at Dante, Va., were examined during the autumn of 1906 by Mr. Ralph W. Stone, one of the geologists of the United States Geological Survey, who had been making a reconnaissance survey of Dickenson County, Va. From notes taken at that time Mr. Stone prepared a brief report published in Bulletin No. 316, which forms Part II of the Survey's "Contributions to Economic Geology, 1906," and contains the results of investigations of coal, lignite, and peat conducted during that year. Dante, formerly known as Turkey Foot, is at the forks of Lick Creek, in the west corner of Russell County, Va., at the foot of the eastern slope of Sandy Ridge below Trammel Gap, in a mountainous country, with steep hillslopes and narrow ridges and valleys. It is near the north edge of the Bristol quadrangle, defined by the Survey, about 8 miles from Fink and St. Paul, on the Norfolk and Western Railway, and is connected with Fink by a branch line known as the Lick Creek and Lake Erie Railroad, which is part of the South and Western Railway. This gives an outlet for the coal to markets north, east, and south. Dante is 10 miles east of Toms Creek, where there are large coal mines and banks of coke ovens, and a number of small mines are in operation between the two places. Mr. Stone describes the coal beds which are mined and the methods of mining employed, and gives analyses of three samples of coal submitted to the fuel-testing laboratory of the Survey at St. Louis. The samples were taken from the beds known as the Widow Kennedy, Lower Banner, and Upper Banner, and the analyses show that they are all high-grade bituminous coals. Mr. Stone states that these coals would probably make a high-grade coke, for the coal mined from the same beds at Toms Creek is coked successfully on a large scale, and the Dante and Toms Creek coals are identical in physical structure and chemical character.

It appears that an important project is soon to be realized in Japan which will bring out the hydraulic resources of that country and utilize them for the benefit of industrial enterprises. The project is promoted by a syndicate with which are connected many eminent Japanese and English persons. An extended report upon the technical side of the question has been drawn up not long since by Mr. Julius W. Howells, one of the engineers of the above syndicate, and he considers that it will not involve a great outlay in order to take advantage of the hydraulic resources of the country. In fact, by constructing a tunnel of only 3 miles' length, some 66,000 horse-power can be taken from a plant situated on the Tashiragawa stream. Another hydraulic plant which will use a tunnel of 10 miles' length extended by an open-air canal, would give about 150,000 horse-power. In the former case there exists a favorable place for constructing a reservoir, and in the second case natural lakes could be made to serve as reservoirs. Another source of power is found in the neighborhood of Nikko, and it is possible to utilize the Chuenji lake as a reservoir; with a tunnel of 3½ miles length in connection with the lake, a head of water of 2,000 feet could be obtained. Besides, in the region of lake Inawashiro, the use of a 3-mile tunnel would afford no less than 50,000 horse-power from a hydraulic plant. Observations made in these regions and a study of the rainfall taken upon a number of years lead the engineers to believe that even during low water periods the above plants would give a total of 300,000 horse-power. A favorable circumstance lies in the fact that the region which is covered by the operations of the syndicate lies at a relatively short distance from Tokio, where it is expected to use the greater part of the current. Of the probable sources of supply which the syndicate has in view, the nearest one lies at a distance of 80 miles from the city and the farthest one at 150 miles. It is estimated that the amount of power which could be used in Tokio is 48,000 horse-power, not counting the current needed for the Tokio-Yokohama railroad or the incline road which is now building in the city. The production of current at a low price will greatly favor the extension of interurban electric railroads, and in general it will be a great factor in the industrial development of the country.

SCIENCE NOTES.

Zwardemaker has constructed, in his physiological laboratory at Utrecht, a room into which no sound can penetrate. The inner wall is made of tufer, lined with horsehair, the outer wall of successive strata of wood, sand, stone and plaster. Hence there are six strata of different fairly sound proof materials, in addition to the air space between the walls. The top and bottom of the room are constructed in the same manner. The room is about 7½ feet in height, length and breadth and is entered through double doors. Not the slightest sound can penetrate the room from outside. The silence is so profound that a normal ear hears a continuous hum, of physiological origin. A sea shell or other resonator held to the ear gives no sound.

The recent burning of the library of Turin and the destruction of numerous rare and ancient manuscripts of inestimable value has called attention anew to the oft-made suggestion that all the valuable manuscripts preserved in the libraries of the world be reproduced in fac simile. The execution of this idea would cost a great deal of money, and governments, being slaves of routine and incapable of initiative, have turned deaf ears to the project. The first move has been made, as might have been expected, by an American, Prof. Gauley, who offered, at the congress of librarians at Liege, to establish in the United States a central bureau for the preservation of negatives of manuscripts and molds of coins and seals, and the sale of prints and casts at the lowest possible prices.

In the Astronomische Nachrichten Denning gives the heights, velocities, and lengths of visible trajectory of the ten largest meteors observed in England in 1906. Meteors, or shooting stars, are small solid bodies which revolve around the sun, generally in great numbers, following approximately the same orbit, and are encountered by the earth in its annual revolution. Then they graze the earth or even fall toward it, but, fortunately for its inhabitants, they seldom reach its solid surface because they are raised to incandescence and dissipated in vapor by the heat generated by friction in their swift rush through the atmosphere. At certain seasons of the year the earth traverses comparatively dense swarms of meteors and is subjected to a veritable bombardment. The meteors of a swarm pursue parallel paths in reality and the apparent radiation of a meteoric shower from a common point is an effect of perspective. For the ten meteors which were specially observed in 1906 the elevations ranged from 55 and 89 miles at the commencement of visibility and from 22 to 56 miles at the moment of disappearance. The longest flight measured was 72 miles and the shortest 24 miles. The velocities varied from 15 to 30 miles per second. In 1904 Fourier and Chandot observed the Perseids or August meteors for six nights and obtained results similar to those given by Denning. The observing stations of the French astronomers were about 6 miles apart. For four meteors the mean height at first appearance was 104 miles, the mean height at disappearance 33 miles, and the average visible flight 90 miles.

The influence of diet upon the digestive tube has been the object of a long series of researches carried out by M. Schepelmann. He fed different fowls, geese especially, upon meat or grain and other food, and in this way obtained modifications which were sometimes quite marked upon nearly all the organs. At present we will mention the modifications which he found in the digestive tube. The results of comparative anatomy establish the fact that carnivorous birds have a stomach with thin walls, while in herbivorous birds the stomach has thick walls. As to the intestine, the fact was brought out by Cuvier and has since been confirmed, that it is short in the first class and long in the second. These facts have been confirmed by tests upon experimental transformism made, among others, by Houssay and Babak. The latter scientist fed tadpoles upon meat exclusively, and he found that their intestine becomes much larger and but half the length of the normal. The results obtained by Houssay, who experimented upon fowl, are analogous. Under the influence of the meat diet, all the parts of the digestive tube undergo a notable reduction. At present, M. Schepelmann finds that the intestine is much longer for geese fed with meat than for the check specimens. This applies especially to the small intestine, as the lengthening of the large intestine and the cæcum are less pronounced. The weight, diameter, and surface of the small intestine, the larger intestine and the cæcum have much larger proportions in the case of geese fed with meat than those which are fed with grain. These experimental results may be compared with certain observations which remained isolated up to the present. Some anatomists such as Werner, Custor, and others already called attention to the considerable length of the digestive tube of certain carnivorous mammals and rapacious birds. It may be true, as Brant claims, that the length of the digestive tube in the case of birds depends upon the faculty of flying which is more or less developed.

TRADE NOTES AND FORMULÆ.

To Make Felt Hats Waterproof.—Mixture: 2,0 parts of ordinary shellac, 500 parts white pitch, 5 parts medium fine glue, 500 parts curd soap, and parts purified potash (crushed fine and mixed in copper kettle on the fire). When fluid add the abo 60 parts of purified potash dissolved in 1,500 parts hot water.

To Dye Felt Black.—Boil some water in a copp kettle and add to it 100 parts of chromate of potas 75 parts of tartar, 15 parts of sulphuric acid. Put the felt (about 1,250 parts), boil gently for 2 hour take it out, allow it to cool and drain 24 hours. The rinse it in the washing machine and dye it in a deco tion of 600 parts of Brazil wood.

Colored Varnish for Tin.—Acetate of copper fine pulverized is spread in a thin layer on a porcelai dish and allowed to stand for a few days. The r sultant brown powder is rubbed down with some o of turpentine and then stirred into some fine fat cop varnish; then transferred to a glass bottle and a lowed to stand a few days in a warm place, being fr quently shaken. According to the heating of the pla the color varies. Use two to five coats.

To Strengthen and Make Waterproof Woolen an Half Woolen Fabrics.—Treat them with a solutio made from 100 parts of alum, 100 parts of animal o vegetable glue, 5 parts of tannin and 2 parts of silica of soda. Two pounds of this mixture is boiled in vessel holding 20 to 24 pounds of water for three hour The water evaporating is to be replaced. The bat is to be cooled to 177 deg. F. and the felt, etc., dippe into it for half an hour. Hereupon spread flat on table for six hours (the fluid draining away to be pr served for future use). Then dry in the same position Finish or calender between two rollers, heated t 132 deg. C.

Varnish for Gold Printing.—Dissolve in a coppe kettle, in 150 parts of water, 50 parts of soda; whil boiling, gradually add, constantly stirring the whil 100 parts of powdered rosin, after which boil free two to three hours and continue boiling until the flui has become perfectly transparent. Allow it to cool pour the fluid off the tough, brown-colored rosin-soa at the bottom of the kettle, add 100 parts of wate and 15 parts of soaked glue, and heat until the com plete solution of all bodies is assured. The varnish thus obtained dries rapidly; if it is desired to hav it dry slowly, add, according to requirements, 10 to 2 parts of glycerine of 28 deg. B.

Cask Enameling.—*a.* 170 parts shellac, 170 parts o dammar gum (thoroughly dried), 375 parts of rosin, 2,000 parts of 90 per cent alcohol. The resins are coarsely crushed, then the alcohol poured over them and set in a sand bath to dissolve. The head is taken out of the dry barrels, the hoops driven tight, and the interior painted by means of a brush. After an hour a second coat can be given. When this is dry the head is replaced, the cask tightened up and the bung hole painted from the outside. *b.* For old casks that have already been pitched, a second varnish is used: 250 parts rosin, 250 parts gum dammar, 275 parts oil of turpentine, 750 parts of alcohol. The mixture is dissolved in a sand bath. The varnishing is done in the open air. The varnish is applied once with a brush, without melting out the old pitch. When this has been done, the cask is laid quickly on a beam, as in pitching. The varnish is not allowed to dry, but about 3 tablespoonfuls are poured into the cask and it is then lighted, the cask being however set upright. The entire varnish takes fire and melts off the old pitch at the same time. Before the flame expires, the head is replaced, and when the hoops have been driven up, the cask is rolled. When this has been done, the spigot and taphole are washed out with water and the cask is then ready to be filled with beer. The brushes, after use, must be wetted with alcohol and placed in the cans containing the varnish, which should then be tightly closed.

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